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Subway Operation in New York City.

The complete success of sub-surface transportation as a means of rapid transit in American cities has been fully demonstrated by nearly four years of operation of the subway of the Interborough Rapid Transit Company of New York City, which subway has generally been conceded to be the best and most efficient underground railway that has been built. As is frequently the case in pioneer work such as this great undertaking necessarily had to be, difficulties were overcome that will not be presented in subsequent similar projects and unexpected new conditions have developed in actual operation. It is always much easier to provide for these things unforeseen to the pioneer, in works which follow first attempts, and also to overlook them in considering what has been produced by those responsible for the original developments along new lines. A report on the capacity of the present subway, submitted to the Public Service Commission for the First District of the State of New York by Mr. Bion J. Arnold, has fully recognized the relative importance of these various circumstances.

Three previous reports on the operation of the subway have been made by Mr. Arnold, the first having to do with the signal system, the second with the type of cars and style of doors, and the third with methods of dispatching trains. The latest report considers in general the capacity of the subway, and makes a resume of former investigations, in so far as the latter have a bearing on the subject in hand. The conclusion has been reached by Mr. Arnold that the proper relationship between the fundamental elements of entering into the enterprise, namely: safety, comfort, capacity, speed and a fair return on the investment, is lacking. It appears that absolute safety has been sacrificed to obtain extra capacity, whereas even greater capacity than is now secured can be obtained by safe methods. The capacity of the subway decreases, Mr. Arnold says, as the load, after the latter has reached a certain point, increases, which is exactly contrary to what might be expected. The comfort of the patrons is also seriously interfered with by the arrangement of entrances and exits, both in the cars and in the stations. Furthermore, the present system of signalling and other arrangements tend to greatly reduce the speed of trains. As far as capacity is concerned, however, the great primary defect shown by the report is that the subway fails to carry sufficient passengers upon a fixed 5-cent fare to justify the investment of $75,000,000 finally found necessary to produce it ready to operate. While this expenditure may seem excessive, it appears certain that the subway could not be reproduced at actual cost for the same amount. However that may be, the report shows that the present subway, which is now overloaded, is not built in such a way as to furnish sufficient capacity, with the conditions under which it has to operate, to produce financial returns consistent with the investment.

This situation might be taken to indicate that the construction of additional subways is questionable from a strictly financial point of view, but Mr. Arnold has determined this is not the case. From his investigations he believes the capacity of the present subway, as now operated, can be increased 60 per cent., and possibly 75 per cent., without greatly changing the construction. The principal changes necessary are said to be in the stations, which represent a small portion of the cost of the entire system, and at branch junction points. The vital result of the investigation is, in any case, the indication that new subways can be built with a capacity from two to three times as great as that now being realized with the present one. It is likewise believed the cost of operating expenses and fixed charges for future subways can be reduced to an amount that will leave from the gross earnings a fair return on the investment in addition to a proper depreciation charge. This conclusion is simply an indication of the progress that is often only obtained by actual operation of works built to meet new conditions presented by the terrific congestion of large cities. The pioneer designers of the great undertaking are rightfully in no manner held to account for the results that have been brought out by the investigation, for as a matter of fact the subway is carrying more passengers than it was originally designed to handle. At the same time, the evidence tending to show the practicability of constructing other subways that will embody the modifications suggested by the results obtained in the operation of this first one, reduces the difficulty of providing funds to meet the requirement for these much-needed means of rapid transit.

The Public as an Engineering Critic.

It is eminently suitable and proper for the public to take a keen interest in all great public works, even though the construction of those works should involve matters of the most technical character. Most great public works are more or less spectacular when located in or near large cities and they attract a kind and amount of attention which would not to any sensible degree exist if works of the same magnitude and general character were built in inaccessible places and beyond the observation of the general public. Such works obviously excite a greatly enhanced interest and cause comment on account of the large expenditures of public money in their construction; they belong to the public, and the public is bound to scrutinize and criticize them. All this is natural enough and commendable, provided comments and criticisms are made in regard to authoritatively established facts, and provided further that there be no other motive than a purpose to ascertain in a fair and proper manner the real nature of the work criticized.

The design and construction of a great public work such as a long-span bridge or a system of water works for a large city are both based upon operations of thoroughly abstruse, technical character, quite beyond the grasp or comprehension of the ordinary newspaper writer. All such design work involves extended analytic treatment by a highly competent engineering staff, supervised and directed by the best professional ability obtainable. It is not uncommon to find many of the computations and other technical operations of such a trained staff seriously influenced by other expert advice in quite different fields of technical science, but of such a character as to exercise substantial influence upon the main operations of design and construction. The construction of a great bridge is influenced materially by various metallurgical considerations bearing upon the quality or character of the steel to be used as well as the capacities of the shop plants and the limits of their effective production. Similarly the construction of the various portions of the great Catskill Aqueduct is being carried on not only in accordance with the design and supervision of the engineering staff of the Board of Water Supply, but the latter is in many cases influenced greatly by the advice of geological experts and specialists in deep mining in connection with the Hudson River crossing, and it is also materially affected by the characteristics and limiting qualities of the materials entering the construction, such as cement and steel. In other words, the controlling elements of final design and construction involve complicated and far-reaching technical considerations which can be appreciated by no one except engineers and others familiar with them by training and experience, and which the general public is utterly unable to gauge, no matter how fully and clearly they may be explained by a technical man. When, on the other hand, the public receives its information and enlightenment from the grossly, because ignorantly, misstated accounts of the daily press it is radically and hopelessly misled.

There certainly can be no objection to the fullest information being given to the public in regard to any great public work, but at the same time it is only fair and right both to designers and constructors as well as to the public itself that that information should come through such channels as will constitute a guarantee of its accuracy and its proper proportions. This is especially true in regard to such information as leads to a comparison of two different structures, some of whose main features may apparently be similar and yet in fact fundamentally different. Nothing is more common in such cases than the publication of the most confident statements that corresponding parts of two different bridges being in general outline quite similar they must of necessity have practically the same carrying power irrespective of the facts that the kinds of steel in the two members may be quite different and that their details of construction may be entirely dissimilar.

While these observations are, and are intended to be of a broad general character, they are forcefully illustrated and confirmed by two unprecidentedly large public works now being built for the city of New York. It was but a short time ago that a prominent member of the daily press began a series of baseless criticisms of the operations of the Board of Water Supply supported only by statements including the grossest misrepresentations of technical facts regarding that Board's works, and a still grosser misinterpretation of those facts and the conclusions which they justify. A subsequent drastic investigation showed that the ordinary reporters' handling of technical matters was radically inadequate and misleading in every respect. The public was misled and had to pay the costs of the investigation and suffer the damage of months of delay in the progress of a great work which cannot possibly be completed too soon to save the city of New York from what may be a ruinous water famine.

Another eminent instance of this kind has lately occurred in connection with the Blackwell's Island bridge, now approaching completion. Another prominent member of the daily press has without any adequate technical basis assumed to pass off-hand judgment on a structure which has been the object of study of a competent engineering staff for a number of years. The newspaper reporter has experienced no difficulty in finding a sure short cut to a confident snap judgment which puts to shame the laborious and carefully planned analysis that it required months and possibly years for engineers to bring to a satisfactory conclusion.

The report of the Royal Commission on the Quebec bridge failure has been read and of course thoroughly understood by reporter-critics and they conclude that as the heavy chord members of the Quebec bridge structure failed under a compressive stress of 18,000 lb. per square inch, the corresponding members in the Blackwell's Island bridge must certainly fail, because a practically impossible combination of loads may stress its heavy compression chord members as high as 24,000 lb. per square inch. As a matter of fact, the ultimate carrying capacity of the compression members in the two structures bear no relation to each other whatever, in spite of their having some general features in common. The heavy compressive members of the Blackwell's Island bridge are formed and braced together as units in the most thorough and rigid manner, while similar members of the Quebec bridge were not; if they had been there would have been no Quebec bridge disaster.

It is well that a competent technical examination of the Blackwell's Island bridge design is to be undertaken, for the public has been too far misled already by the reporter-critics. Let the public withhold its judgment until it is determined by competent authority whether the carefully and thoroughly developed computations and other procedures of design of the Department of Bridges or the irresponsible newsmonger is more nearly right.

Some Questions on Vibration.

In these days of subway building, when men are doing their best to build subterranean cities, as well as skyscrapers, it is pertinent to inquire what the effect of modern methods of rapid transit is upon the foundations within their territory. It is possible at present to excavate a tunnel even through the heart of a city and at a comparatively high level without much immediate disturbance. When, however, the tunnel is put into service for rapid transit there begins a perpetual course of racking and vibration that may produce in time effects which at the moment seem quite out of the question. Even the operation of an elevated road reaching the earth only by oscillations imparted to it by the supporting structure may cause buildings to vibrate and similar results are likely to occur in subway operation. The vibration is, in the case of some rapid transit systems, rather easily noticed once one's attention is called to it, and it sometimes is within limited areas astonishingly evident. If one goes along a street on which an elevated line is in use, or which is above a subway and merely stands quietly as a train goes by above or beneath him he will immediately note the vibration and after a little experience in the observation can locate it easily and even follow it up side streets for a hundred feet or so.

Under ordinary conditions the period of the oscillation is short, a mere fraction of a second, but it continues to be in evidence as a tremor for some seconds, until, in fact, the train is well by. The amplitude is also generally small, and it is the considerable rapidity of the action that makes it so easy to notice. If an earth vibration is rather slow, as in the case of transmitted waves from distant earthquakes, its amplitude may be considerable without attracting any particular attention. It is the rapid horizontal component of a vibration that probably engages the attention most readily. The effect of these traffic vibrations is probably slight in firm ground on account of the small amplitude. In particular places, however, the constant shaking down process is likely to produce settling. Buildings founded on made land are perhaps the most likely to suffer, the filling being somewhat imperfectly done and of materials lacking in stability. The foundation that in such situation would stand static pressure very well may behave badly when subjected for months or years to the vibration dispensed by trains. The action is likely, too, to be cumulative, showing no immediate sign of strain.

At all events, the danger is sufficient to justify watching the situation pretty carefully whenever there is a chance of damage. On the other hand, it would seem to be the part of wisdom to plan subway roadbeds, as well as elevated lines, with some reference to the suppression of vibrations. So far as the elevated road question goes there is the additional reason of suppressing noise which on some lines has proved to be extremely annoying and the source of serious damages. There ought to be some material available which would be capable of absorbing much of the vibration that would otherwise be transmitted to the structure. Some experiments have been made in this direction with fair results already, but much yet remains to be done. The same treatment that would check noise in an overhead structure would at least partially suppress vibration in an underground one. How well various types of building stand small continuous vibrations is as yet unknown. Most of the observed injury has been to brick and stone structures, especially the former, probably merely because the commoner. Modern steel buildings would hardly be injured, unless by the foundations working out of level. There are places where there is very perceptible vibration and it would seem to be good policy to investigate these a bit with reference to possible progressive damage. It is not unlikely that there may be a good many cases of settling and cracking from unrecognized causes which are really due to persistent forced vibrations of such sort, perhaps originating at a distance of several hundred feet. One sometimes finds special localities to which vibration is very strongly carried, while spots nearer to the sources may be relatively free from trouble. It is merely one more of the risks incident to a complex civilization, and which may be minimized by suitable precautions, even if it cannot be entirely abolished.

Power Plant Operation by the Consulting Engineer During Reconstruction.

In the reconstruction of large-capacity power plants one of the questions which arises for early solution is the method of operation desirable during the period of improvement. The first requisite is that the changes shall be carried out with the least possible interference with the continuity of service in the plant. When this condition has been met for each particular case the next features to be considered are the completion of the plans at a minimum expense and the maximum economy of power production consistent with the existence of abnormal conditions lasting from several months to a year or more.

The exact nature of the changes under way in each case largely determines the extent to which operating economy and unimpaired service can be enjoyed, and whether the regular organization of the plant can assume full charge of power production independently of the alterations in the station. If the changes are mainly in the nature of extensions along well-established lines, with the installation of new equipment in an addition to the original building free from the old apparatus, it is not likely to be necessary for the operation of the plant to be supervised by the consulting engineering organization during the time the new machinery is being installed. If radical departures from the previous type of apparatus used in the station are contemplated, however, or if the introduction of improvements involves the alteration of existing boiler, piping, auxiliary or generating unit layouts, with relocations for a more flexible operating scheme in the completed plant, the services of the consulting organization may be made extremely valuable in holding the plant up to the best attainable practice while it is undergoing the necessary transformation. If the production problem as a whole in a given station is assigned to a firm of consulting engineers for solution on a clear definition of responsibility for results attained it is certainly a wise procedure to provide in the contract between the engineers and their client for such supervision of actual operation during construction as will insure the best handling of the situation as it changes from month to month. Such a case is analagous to the supervision of the operation of power plants, distribution systems and rolling stock by the engineering organization of an electrified steam railroad in the electrical zone during the period of construction, installation and adjustment of the new motive power.

It has for some time been recognized that the operating economy of a varied assortment of machinery assembled in a group as a single power plant ought to be more definitely determined in advance. In spite of the progress that has been made in the past ten years or so in reducing losses in the fireroom, the pipe systems and auxiliary equipment, and the accuracy with which the efficiency of individual machines can be forecasted, it is still a very difficult problem to determine the economy of a plant as a whole by integrating the losses in the main and auxiliary units as indicated by the individual guarantees. The closer the control of an installation on the operating side by a firm of experienced engineers during modifications of the equipment, the broader is the opportunity to secure data that will in time be of great assistance in the planning of harmonious installations. On account of the established facilities for measurement of all the factors entering into power cost in a plant with considerable commercial service in its history, there is an excellent chance for the engineers in control of operation during the execution of changes to obtain scientific knowledge of those changes in their effect upon the entire service of a station. The adjustment period properly watched and recorded is one of the most suggestive experiences in practice, and it may be made no less helpful to the individual plant than to the engineering profession at large through the ability of the staff in charge of the work to select diverse apparatus with greater skill in future installations.

Control or at least close supervision of operation enables the advisory engineer to take prompt advantage of all the conditions that arise as the work proceeds, and often with little or no interference with the regular service. The operating staff of a station being confined to its service all the time, cannot always appreciate the various ways a given problem in the administration of reconstruction can be solved. Consequently, if authority is granted to the engineer responsible for the changes to determine the order of operation, it will frequently happen that time and expense can be saved in the handling of the work, on account of the broader opportunity for observation and treatment of difficulties possessed by him, in comparison with the more circumscribed horizon of the local operating officials. Co-operation is, of course, infinitely preferable to lack of harmony between the local staff and the staff of the consulting engineer, but authority needs to be clearly defined at the outset if the greatest good is to result. Even where the consulting engineer maintains a local office in the city where the work is being done, it is not feasible in most cases for his representative to be at the plant all the time outside construction hours, and the cordial assistance of the station staff is indispensable to the highest success in the study and practice of the fine art of equipment interadjustment. A change in piping to meet some temporary condition may seem radical to the chief engineer of a station, but to the more experienced and more highly specialized engineering organization in control of the work as a whole the change may be merely incidental to a larger good.

Authority to modify the operating practice of a plant, coupled with the tact which is indispensable to any business success, will carry the engineer retained to improve property through most crises of opinion between himself and the local plant force. When it becomes necessary to discontinue the use of a certain battery of boilers, for instance, in moving it to a different location in the station the provision of the steam supply from the remaining or newer units and the arrangement of the temporary piping are matters closely related to economy, flexibility and reliability of operation. Together with the modifications necessary in coal handling, they will logically be considered at length in the office of the consulting engineer. On the other hand, the proper time to carry such changes into effect, the tendencies of the station load curve at different periods, the ability of the old machinery to withstand forcing, the extent to which any new units can be counted upon for help in the transition stage and the success with which new and old apparatus can be operated in multiple are not points to be determined from an office chair, without prior close personal contact with actual operating conditions. Even with a considerable amount of such observtion much information regarding details is to be obtained only from members of the regular operating staff of the plant under consideration.

Notes and Comments.

The Scleroscope is an instrument devised by Mr. Albert F. Shore, with the assistance of Dr. Paul Herould, to measure the hardness of metals. It consists in essence of a glass tube, within which a steel ball of 40 grains' weight, treated by a special process so as to have jewel hardness, falls freely. The height of the rebound of the ball measures the hardness of the metal it strikes. Were the area of contact between the dropped weight and metal larger, so that no appreciable dent were made, the rebound would be a measure of elasticity rather than hardness. The height of the rebound is measured on a scale, of which 100 is the average hardness of carbon steel, which is also found to be the safety limit for steel tools after reheating and tempering ready for use. Mr. Shore states that the instrument will be found very useful in the manufacture of tools like twist drills, where the hardness has to be kept between narrow limits.

Flood Prevention goes hand in hand with water conservation in northern Bohemia, where a water association has been formed in one of the most important river basins that deserves careful study by owners of American power plants along mountain streams. This association has already built five dams at a cost of about $1,500,000, and another will be built; the reservoirs are kept about half-full normally, so that there will be plenty of storage capacity for flood waters. Every land or water-power owner whose property derives any benefit from one of these dams must be a member of the association and contribute from $2 to $1,015 per annum to its funds, according to the nature and amount of the benefit afforded. The money to pay for the construction of the dams was raised partly by subvention, Austria contributing 30 per cent., Bohemia the same amount, Saxony and German Silesia about $166,600, while the balance will be raised by the membership dues of the association.

Garbage Reduction in this country has had such a checkered career that it is highly refreshing to learn in detail of the satisfactory results that have been obtained with this method of waste disposal in the municipal works at Cleveland. A paper by Mr. W. G. Springborn, that was printed in last week's issue of The Engineering Record, describes these works with unusual clearness, covering the cost of operation and maintenance, as well as the design of the equipment and the methods of handling materials. From this description it is evident that the works have been practically rebuilt and newly equipped since they were purchased by the city in 1904. The steel wagons used in the collection of the garbage and the steel railroad cars in which the latter is transported to the works, nine miles from the city, are important features of the system, since they have been evolved by experience as being best adapted to the conditions. The method of reduction is in general similar to methods used in some other places, but it has been developed with the same care which is characteristic of the evolution of highly efficient manufacturing processes. On this account, it is not surprising to know that specially satisfactory financial results have obtained and that the cost of operation is being continually further reduced. It is furthermore evident from the description, that these works have received the proper technical treatment being accorded more generally in this country to every phase of refuse and garbage collection and disposal.

Rapid-Sand Filtration Results have been made public from time to time in more or less detail, but the discussion of the operation of the filter plant at Ithaca, N. Y., by Professor E. M. Chamot, which appeared in last week's issue of The Engineering Record is based on data obtained under conditions more favorable to careful control and observation than are usually possible. The discussion is consequently of especial interest to those who have to do with the operation of such plants. It is also valuable to engineers as marking the return to the use of filter surface water after a serious and expensive, though ultimately unsuccessful effort to replace such a supply with water from underground sources. It is evident from the discussion that the plant has been studied in very great detail to determine the conditions of greatest efficiency, and specially with reference to adapting it to meet the changes in conditions which frequently occur with a flashy stream similar to the one from which water is handled in this plant. In this respect the conditions with which Professor Chamot has contended have been widely different from those in a number of other similar plants in this country. The record of average bacterial results, and of a reducing death-rate with a rapidly increasing population, certainly show that the filters have been made to accomplish the desired results. It is also evident that the coagulation and the work done in the coagulating basis form a very large part of the whole purification. The conditions of efficient operation of this basin and the expedients resorted to at special times to increase its efficiency are certainly of the greatest interest and value.

Missouri River Improvements between Kansas City and St. Louis are being advocated locally in more than the usual ardent manner, since the appearance of a recent report to the War Department by Captain Edward H. Schulz, Corps of Engineers, U. S. A., which report is held to show that these improvements are feasible. Two plans are presented, one for providing a uniform 12-ft. channel from Kansas City to St. Louis at a cost of $20,000,000, and the other providing for a temporary 6-ft. channel at a cost $3,000,000. The lesser channel work would be a permanent undertaking and could be made the basis for the final improvement. While the Missouri is generally understood to be specially elusive in so far as maintaining it in one channel is concerned, the report states that on the portion of the river where continuous, systematic work was made possible with the abbreviated funds available under the former Missouri River Commission, the result obtained has been remarkable. From Jefferson City to the mouth of the Gasconade, in a distance of about 45 miles, a continuous channel with a depth of not less than 6 ft. was secured over what was originally the worst part of the river. In 18 miles the area of land recovered was 5,500 acres and the area of land protected was 12,800 acres. Although this work was done 12 years ago, the channel has remained practically intact without any repairs. From these results it would appear practicable to control the stream and to create a permanent, navigable channel. A feature of nearly as much significance brought out in this connection is the reclamation and protection of such a comparatively large amount of land. The immense areas of swampy land and of periodically-inundated tracts along the rivers of the Middle West can be made to play an important part in any scheme for channel improvements. It is true that much of this highly fertile land has been reclaimed and protected already by private interests, as well as by the Government. The acreage remaining to be rendered available for cultivation, with results as certain as in an irrigated district having a sufficient water supply, are so remarkably extensive as to render this phase of channel deepening one of peculiarly growing importance as the interior of the country becomes more densely populated.

HYDRO-ELECTRIC PLANT OF THE LA CROSSE WATER POWER COMPANY.

By Geo. Merritt Ward.

In the old forest lands of central Wisconsin are several streams of considerable size which carry the rainfall of that wooded state on its journey to the sea. These streams in the course of their descent often flow in narrow valleys and have a heavy fall through most of their length, a feature especially valuable for hydraulic power development. Several water-power plants have already been constructed and others are projected on streams in or near this land of the Pine.

The Black River is one of the upper tributaries of the Mississippi, long known as one of the many logging rivers of the Wisconsin timber lands and draining a basin of approximately 1,200 square miles above Hatfield, Wis., where the La Crosse Water Power Co. is constructing a plant of 16,000-hp. capacity to utilize to the best advantage a series of rapids occurring at that point. The total fall available is 91 ft. from the normal surface level of the water in the forebay to that in the tail-race. The average flow of the river is approximately 600 cu. ft. per second at the site of the dam, which will impound a reservoir with an area of 650 acres and with a maximum depth of 50 ft. and an available depth of about 10 ft., as the river basin at this point narrows down from a wide plain to a deep rocky channel, making the site an ideal one for water storage.

The hydraulic development consists essentially of a reservoir, dam, spillway, canal, forebay, penstocks and wheels, from whence the water is discharged into a tail-race and returns to the river. The plant will have a capacity of 9,600 kw. for the transmission of a three-phase, 60-cycle, 44,000-volt current.

The dam is a structure of cyclopean concrete, giving a spillway of 490 ft., flanked on each side by abutments of the same material and earth dikes extending 1,500 and 2,800 ft. from each end. The dam itself has a maximum height of 49 ft. and width of base of 49 ft., its section being of a standard "ogee" type. The canal head-gates contain three 20-ft. steel Tainter gates of 9.5-ft. rise, by which the flow into the canal is regulated. The earth dikes have a maximum height of 31 ft., side-slopes of 2 to 1, 4-ft. berms, and are made impervious by concrete core-walls founded on bedrock. The core-walls have a thickness of 2 ft. at the top and a batter of 12 on 1 on each side. A floating log boom will protect the head-gates from heavy driftwood.

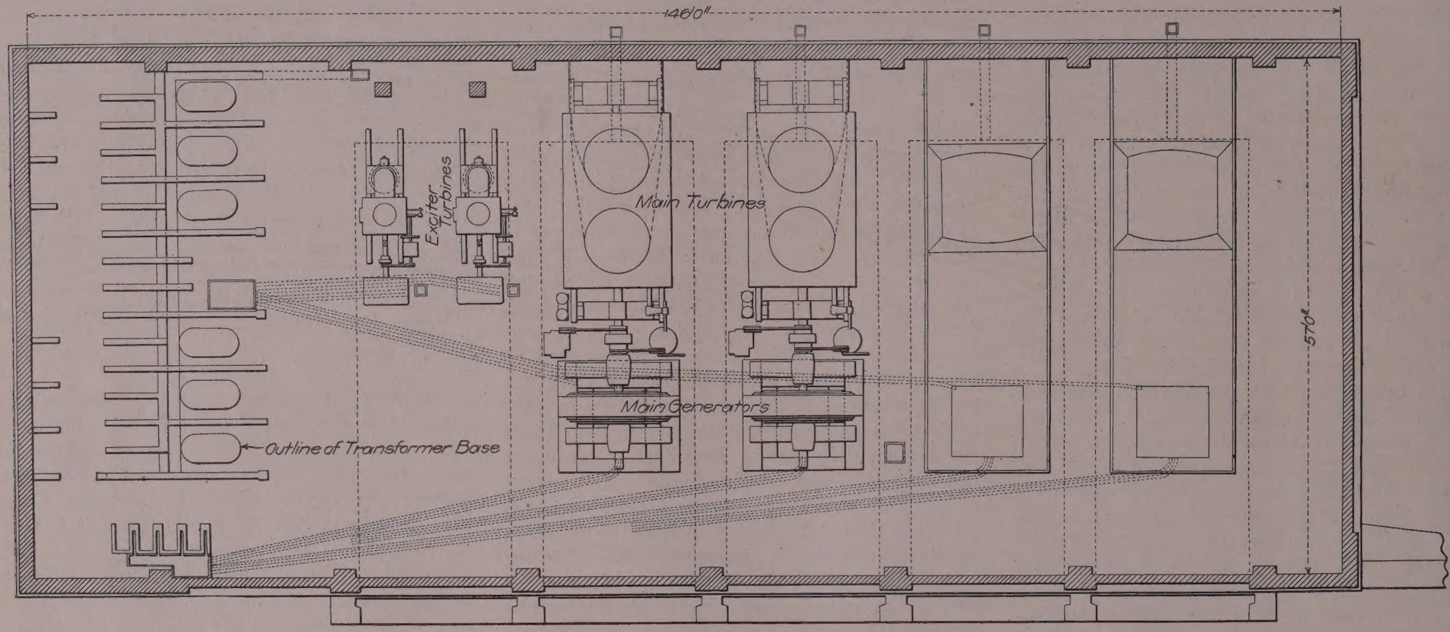
Immediately below the head-gates on the river side of the canal is placed an auxiliary spillway, having an elevation of 2 ft. more than the main dam, without flash-boards. This spillway serves to regulate the water elevation in the canal and forebay during high water.

The canal, conveying the water from the dam past the rapids in the forebay beyond, is approximately 2½ miles long. One bank of the canal consists, throughout most of its length, of a cut in the hillside; the other, or river side, of an earth fill. This embankment, having a maximum height of about 30 ft., has slopes on each side of 2 to 1, a width of 10 ft. at the top and a berm of 4 ft. In the higher portions the section is increased and a core-wall provided. The material encountered to date has been sand or coarse sandstone in the process of formation, necessitating in places the laying of a gravel-clay lining.

The canal is widened out to a base of 50 ft. for the last 4,500 ft., forming a forebay intended to keep a fairly constant surface elevation under sudden changes of gate. The penstock head-works at the end of the forebay is built of concrete and contains trash racks, penstock and waste gates and air vents. The penstocks are of double-riveted boiler plate and are firmly held in concrete anchorages at the forebay and power-house; and throughout their entire length concrete pedestals support them at intervals of 16 ft. Four of the penstocks connected to the main generator-turbines are of 10-ft. diameter, while that feeding the exciters has a diameter of 3.5 ft.

The power-house is 146 x 57 ft. in plan and 34 ft. high from the floor to the lower chords of the roof trusses. From a level 2.5 ft. above the dynamo floor the structure is principally of brick and steel; but below it is of monolithic concrete, arching the tail-races. To the south of the power-house is the transformer room, switchboard gallery, and so forth, 57 x 26 ft., the remaining space being occupied by the turbine-driven generators. The building has a roof of 2-in. tongue and grooved planking, with slate covering, supported on steel trusses of the Fink type.

Although provision is made for four generator turbines, only two are to be installed at present. Each main unit is a pair of horizontal, 39-in. special Smith wicket gate-wheels, with central discharge direct connected to the generators. The wheels operate at 300 r.p.m., and each unit is guaranteed to develop 4,000 hp. when working at full gate under 86-ft. head. Each of the exciter turbines is a pair of Smith wheels of the same type, guaranteed to develop 250 hp. under the same conditions. The draft tubes are about 15 ft. long. Those for the generator units are 10 ft. in diameter and extend 1 ft. below the extreme low surface of the tail water. For controlling the gates of the main generator units type N Lombard

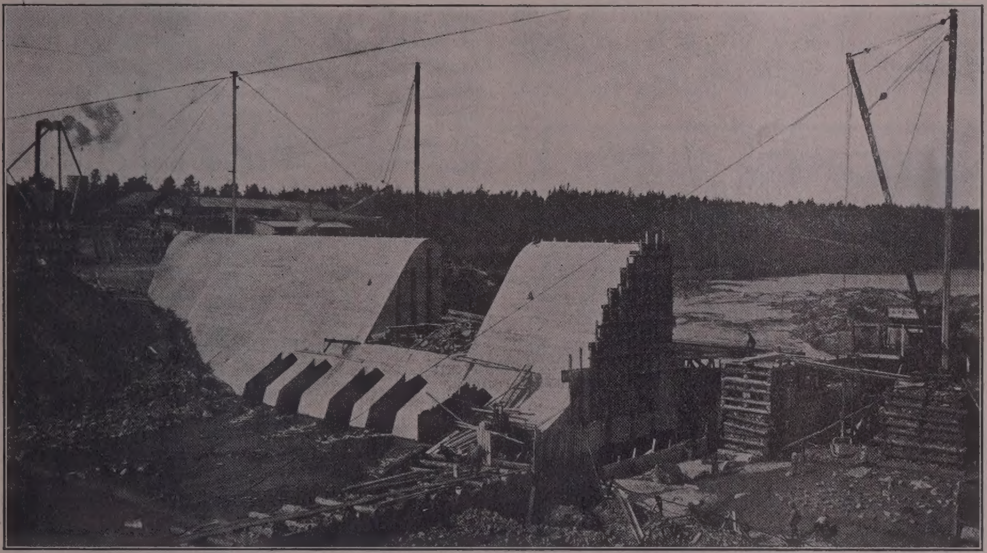


General Plan of Power-House, Showing Arrangement of Wheel Bays.

A Construction View of the Head-Works, Showing Contractors' Plant Employed.

governors will be used, and for exciter units type D Woodward governors are provided.

The electrical equipment will ultimately consist of four 2,400-kw., 3-phase, 60-cycle, 2,300-volt generators of the horizontal-shaft, revolving-field type, direct connected to the turbines and operating at 300 r.p.m.; two exciter units of 125-kw. capacity, compound wound; six step-up, water-cooled oil transformers, lightning arresters, switches, and so forth. The main generators are guaranteed to carry a 25 per cent. overload for two hours, with a rise in temperature not exceeding 55° C. Either exciter is capable of furnishing excitation for the complete installation and can also be used for operating an electric crane.



Spillway of Dam under Construction in Sections.

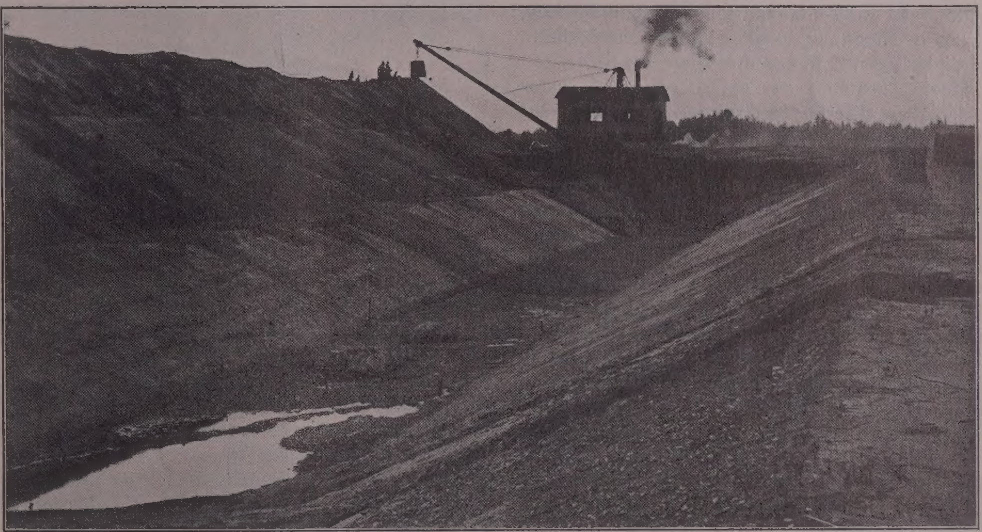
A 25-ton Whiting hand-power traveling crane, running the entire length of the building, has been provided.

Construction.—The preliminary construction work, such as the erection of the camp and the clearing of the dam and canal sites, was begun in April, 1907, and in the following June work was under way with full force. The first concrete of the dam was laid in July of last year, and it is expected that the plant will be in operation on Jan. 1, 1909.

The first step in the actual work of harnessing the river consists in building at the site of the head-works the cofferdam, a rock-filled timber structure, 500 x 150 ft., the natural bank forming one side, thereby diverting the water into the east half of the river channel and allowing the excavation for the dam to be carried in the dry to bedrock.

Concrete mixing plants were erected on each side of the river, containing three No. 4 Ransome mixers. An excellent granite quarry was opened up on the east side of the river, where a crushing plant of considerable capacity was erected, the broken stone being carried from there to the bins of the mixing plants by construction trains. Sand and gravel was obtained from a borrow pit nearby with drag scrapers, screened and brought to the bins in dump-car trains. Cement was kept in an adjacent storehouse and wheeled by hand to chutes immediately above the mixers. The mixture was in 1-yd. batches, in the proportions of 1:2½:5, using Atlas Portland cement. About 150 yd. is the average daily output of each mixer. The concrete was delivered in 1-yd. tipping buckets and placed in the forms by means of push-cars and 5-ton, 60-ft. boom guyed derricks. These derricks were operated by Lidgerwood and American double-drum engines and were the limiting factors in the daily progress. Plum stones up to 1 yd. in volume were bedded in the concrete and formed about 25 per cent. of its mass. Lifts of 3 to 8 ft. a day were secured, care being taken in filling the forms to complete a horizontal course over the whole surface. Successive fills were bonded together by large stones imbedded so as to project halfway above the surface of the lower course and so lock with the subsequent layer. The forms were built of 2-in. dressed pine planks, braced with 4 x 6-in. studding, spaced 3 ft. apart on centers and stiffened with 6 x 8-in. horizontal waling pieces attached every 4 ft. The forms were anchored with heavy iron wire, or ⅛-in. band iron, and were not interchangeable, being knocked down as each section was stripped and rebuilt for the next.

The dam was constructed in alternate sections, 40 ft. long, bonded together with vertical trapezoidal keys, 3 ft. apart in the clear and terminating 2 ft. below the upper surface. Upon reaching the center the end cofferdams were removed and rebuilt across the east channel, sending the water through five 10 x 10-ft. sluiceways left temporarily in the structure. The excavation was then pushed forward in the last channel, and on Dec. 3 the last bucket of concrete was placed in the closing sluices.



An Excavator in Operation on the Canal, La Crosse Water Power Plant.

The canal is being constructed with three excavators, using Page dippers and Lidgerwood machines. As the material is principally a coarse sand, these machines are peculiarly adapted to this work.

The power-house was built with a plant very similar to that used on the head-works. Three 5-ton, 60-ft. boom guyed derricks and a No. 4 Ransome mixer were rigged, and with this plant most of the excavation and concrete work was handled.

The contract for the construction and installation of the entire development, which embraces, among other things, the following quantities—19,000 cu. yd. of excavation for foundations; 420,000 cu. yd. of excavation for the canal; 31,000 cu. yd. of embankment; 30,000 cu. yd. of concrete, and 470,000 lb. of steel—was awarded to J. G. White & Co., Incorporated, of New York City. The General Electric Co. are furnishing the electric machinery, and the S. Morgan Smith Co. the hydraulic machinery.

Mr. W. J. Ferris is general manager, and Mr. W. C. Woods is engineer of the La Crosse Water Power Co., of La Crosse, Wis. The company has offices both at Hatfield and La Crosse, Wis., and contemplates furnishing light and power to La Crosse, Winona, Minn., and their immediate vicinity.

Liverpool Dock Improvements.

The present inadequate dockage facilities of the port of Liverpool are to be improved so it will be possible to dock vessels up to 800 ft. in length, which is greater than the length of the largest vessel afloat, without waiting for high water. Vessels of over 600 ft., which can now only enter at high water the lock leading to the docks, will be enabled to enter and leave the latter as soon as there is high water on the outer sill of the lock. The undertaking involves the expenditure of $16,022,000, and includes the following works:

A vestibule or half-tide dock, with a river lock entrance, 870 ft. long and 130 ft. wide, and having a sill 30 ft. below the existing dock sill; the foreshore in front of this entrance is to be lowered to suit the sill level, and the river wall reconstructed. This portion of the project is estimated to cost $6,890,000. A lock, 645 ft. long and 90 ft. wide, with sills 20.5 ft. below the present sills, is also to be provided between this half-tide dock and an existing dock, at a cost of $1,024,000. Two branch docks, one 1,295 ft., and the other 1,265 ft. long, and each 100 ft. wide, are to be built in connection with the half-tide dock. Along these branch docks will be two-story pier sheds which will cover a combined area of over 27 acres.

The significance of the 30-ft. sills in conjunction with the 870-ft. lock is very great, as at high-water neap tides there will be a depth of 40 ft. over the sill, and at ordinary spring tides a depth of 50 ft. This will permit large vessels to enter the lock long before and after high tide, and to be passed through into the system of docks, whereas they can now only dock at high water.

Geologic Basis for Artesian Prediction

Abstract of a paper read before the American Water Works Association by N. H. Darton, geologist, U. S. Geological Survey.

Many persons do not know the conditions of occurrence of underground waters, but have vague ideas of subterranean rivers and lakes. They do not realize that there are water-bearing deposits which are just as definite in their geologic relations as the strata which carry coal and most other mineral products. The study of underground water problems is a special branch of geology which has had rapid development during recent years, and now the prediction of artesian and other ground waters is on a sound geologic basis. This later statement is substantiated by the fact that a very large number of predictions have been verified by notably successful wells. The subject of underground waters is an extensive one, because of the diversity of geologic conditions in different parts of the country, but Mr. Darton pointed out only some fundamental principles which guide the geologist in making artesian predictions.

One of the most important considerations is the fact that a large part of the earth's crust consists of thick layers of alternating sandstones, limestones, shales and other rocks often lying nearly horizontal, but more frequently flexed into extensive arches and troughs. Many districts are underlain by crystalline rocks, such as granites and gneiss, while on the surface, especially along the river valleys and in lake basins and in the glaciated province, there are deposits of gravels, sands and clays. Some regions are covered by sheets of lava. In these features occur most of the artesian water problems, but naturally with great diversity of local conditions. One of the most important conditions and the one to which the greater part of the paper was devoted is a widespread sheet of sandstone overlain by clay, shales or limestone, sloping into a shallow basin or dipping gently in one direction.

Most sandstones are porous, and the water which they absorb from rainfall and sinking of streams in the surface outcrops flows slowly underground through the interstices. If the ground is higher on one side of the basin than on the other, of course the water will flow slowly from the higher to the lower side, provided the sandstone is covered by clay or other impervious or less pervious material to prevent or impede leakage. This condition is shown in the accompanying Fig. 1. That the waters flow slowly underground through sheets of sandstone is demonstrated in most instructive manner in the great artesian basin of the Dakotas. The water passes into the sandstones in their elevated outcrop zone along the foot of the Black Hills and Rocky Mountains and flows east through the permeable rocks, finally to escape in springs in the lower Missouri Valley. The sandstones are overlain by a thick mass of clay, and, as the intake zone has an altitude of 4,000 ft. or more and the region in which the principal wells have been sunk is only from 1,200 to 1,400 ft. above sea level, the water is under great pressure. The existence of this pressure is the strongest evidence known that the waters flow underground for many hundreds of miles. Several of the wells show surface pressure of over 175 lb. to the square inch, and two are slightly over 200 lb., the latter indicating a pressure of 780 lb. to the inch at the bottom of the well. Some flows are from 1,000 to 4,000 gal. a minute. Such pressures can only be explained by the hydrostatic influence of a column of water extending to a high altitude at the intake zone. If it were not for the outflow of the water in springs to the east the pressures would be much higher. Owing, however, to this leakage, the initial head is not maintained, and there is a gradual diminution of head to the east, known as hydrostatic grade, a slope sustained by the great friction of the water in its flow through the relatively small interstices of the sandstone.

In the accompanying Fig. 1 is given a profile across an artesian basin showing the hydrostatic grade which determines the head or height to which the water will rise. The solid line is the land profile; the broken line, the hydrostatic grade and the water is contained in the sandstone. The reason for flow in a well at *A* and for lack of flow in a boring at *B* is evident. The accompanying simplified map of a typical artesian region in central South Dakota, Fig. 2, similar to the one shown in Fig. 1, indicates the manner in which the area of flow is platted. The head of the water diminishes to the east, owing to the outflow in the southeastern corner of the state. The water-bearing stratum underlies all of the region at depths of 2,000 ft. or less and reaches the surface along the outcrop zone shown by the line of *X* on the left of the diagram. The altitude in the valley along this outcrop is 3,300 ft., and that is the initial head of the water. A well reaching this stratum in the southeastern corner of the diagram at an altitude of 2,770 ft. has a closed pressure of 100 lb. to the square inch, which indicates a head of 3,000 ft., or, in other words, the water has pressure sufficient to rise in a tube 230 ft. above the mouth of the latter. This indicates a regular gradient from 3,300 ft. at outcrop zone to 3,000 ft. at the well. Accordingly, headlines for 3,100, 3,200 and 3,300 ft. are drawn equidistantly on the contour map, as shown by the broken lines in Fig. 1. Having the altitude of head and altitude of the land on the map, it is a simple matter to plat the hydrostatic grade by a line which delimits the flow area. This line crosses the 3,200-ft. contour line at the intersection of the 3,200 headline, and so on. The figure shows that a projected well at *A* may expect a flow, while *B* lies slightly too high for one. The pressure to be expected at *A* may be calculated easily. A few years ago the writer predicted flows in central South Dakota on this basis, and recently several successful wells sunk along the new railroad lines have verified the prediction in a most gratifying manner. Suppose the altitude of the land is 2,950 ft., as shown by the contour lines, and the head is 3,100 ft., the height to which the water would rise above the surface is 150 ft., equivalent to a pressure of slightly over 65 lb. to the square inch. Good contour maps are important in underground water predictions, but in their absence suitable lines of levels can be run which will afford basis for head determinations.

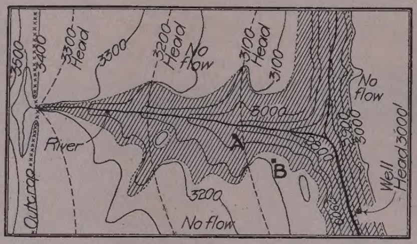


Fig. 2.—Contour Map.

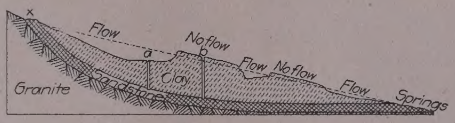


Fig. 1

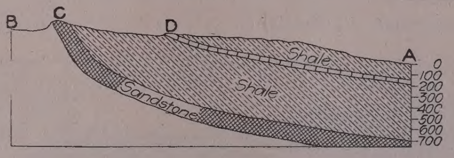


Fig. 3

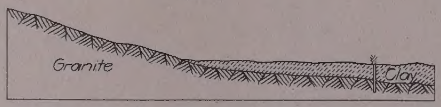


Fig. 4

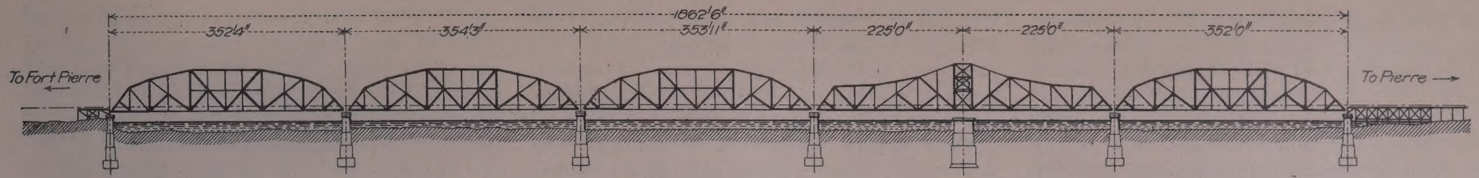
Typical Occurrences of Artesian Supplies.

The determination of depths to deep artesian waters in stratified rocks sometimes can be readily made from few data, but it frequently happens that it must be based on an extended examination of the local geologic conditions. The principal basis is knowledge of the thickness of the strata, and, while for many regions the facts are already available, in others it is necessary to trace the strata to their surface outcrops, which often are many miles from the locality in question. The structure of the strata in the intervening country also has to be carefully considered. The records of borings anywhere in the neighborhood throw much light on underground relations, although in many cases they are so poorly kept that they are highly misleading. Samples of strata penetrated are much more valuable, especially if they have been carefully collected and labeled. An ideal condition is shown in the accompanying Fig. 3.

In this figure suppose that a boring is desired at *A*. The geologist, from an examination of the country from *A* to *B*, which may be a distance of many miles, concludes that the only promising water-bearing rock is the stratum outcropping at *C*. By carefully measuring dips of the strata from *C* to *A*, especially if aided by a distinct bed, as at *D*, he can construct a cross-section such as the one given in the figure. On this section he can base a prediction that at *A* the top of the water-bearing stratum may be expected at a depth of 700 ft., providing the strata do not thicken or thin materially in the distance. An interesting illustration of such a prediction is at Edgemont, South Dakota, where the writer estimated that the sandstone would be found at a depth of about 3,000 ft. Recently the Chicago, Burlington & Quincy R. R. struck it at 2,965 ft. and obtained a large flow.

In the case of granites and other crystalline rocks the artesian problem is very different from the one above outlined. Ordinarily such rocks are not underlain by a porous stratum, and the fresh rock is too compact to carry any water supply. They are, however, usually broken by joint planes and often deeply disintegrated, so that more or less water is stored in their upper portion. Some of the crevices extend for long distances and pass under clays or other deposits in lower lands, so that head is established. When a crevice of this kind is struck by a well, such as the one shown in Fig. 4, an artesian flow is obtained. The occurrence of water under such conditions is difficult for the geologist to predict, but in some places the rock structure is so evident that it may guide to a successful forecast.

Some of the negative features of underground water are of great importance. In many localities it is evident from the geologic conditions that no water supply can be obtained, and in such places it is possible to avoid the great waste of expense of a deep boring which cannot succeed. In some cases this condition is evident from geologic facts at the surface, while in others it can be inferred from the samples of boring after certain beds have been penetrated. Frequent instances are available of deep borings made in compact granites or other crystalline rocks which could not succeed, or in shales which it is known are so thick that underlying strata could not be reached by the means available. It is probable that in the aggregate the warnings against hopeless borings have been even more valuable than the predictions that water would be found. These warnings have saved the waste of a very large amount of money, but sometimes they will not deter the driller who has some notion of his own which he believes is of greater value than the scientific deductions of the geologist.



General Elevation of Missouri River Bridge, at Pierre, South Dakota.

The Missouri River Bridge of the Chicago & Northwestern Railway at Pierre, South Dakota.

The Chicago & Northwestern Railway crosses the Missouri River between Pierre and Fort Pierre, South Dakota, on a single track bridge, about 2,620 ft. long, which includes one 450-ft. swing span, four 350-ft. fixed spans and 752 ft. of permanent timber trestle approaches. Part of these approaches may eventually be replaced by solid fill, and a 1,200-ft. temporary trestle that extends from one end of the permanent approach is intended to be immediately superseded by embankment as soon as earth for the fill is conveniently available from other construction operations.

The axis of the bridge is nearly at right angles to the river banks and is located where there is a maximum low water depth of about 11 ft., and a velocity varying from about 3½ to 5½ ft. per second. Eight test borings in the line of the bridge indicated approximately horizontal strata of sand and gravel overlaying a uniform bed of gray clay shale about 43 ft. below low water. Care was taken to locate the bridge so as to avoid as much as possible the danger often encountered in Missouri River crossings by the tendency of the river channel to shift between wide limits, thus making it possible that the original spans may at some future time be left on dry land and new spans be required for the changed position of the channel. At this point, however, the channel now crosses from one bank where it is restricted by shale bluffs extending five miles up stream, to the opposite bank where it is similarly restricted by bluffs of the same character extending six miles down stream and thus making it very improbable that any material change in its location can take place.

The substructure includes a circular pivot pier and a triangular protection pier for the draw span and six regular piers for the fixed spans, all of them made with concrete foundations carried down about 5 ft. below the surface of the shale formation by means of wooden pneumatic caissons. In order to prevent danger of scour from the constriction of the channel by the piers built in it, one bank is protected for a distance of about 500 ft. upstream and 100 ft. downstream by a standard revetment with a minimum width of about 86 ft. reaching 80 ft. beyond the standard law-water contour. This revetment consists of a continuous woven-willow mattress from 12 to 18 in. thick, with ⅜-in. longitudinal and transverse galvanized-iron wire ties fastened to old pile butts or stone dead-men and covered with ¾ cu. yd. of rip-rap per lineal foot; and the inshore end is covered with small spawls. The upper bank from standard low water to 2 ft. above high water is made with rip-rap from 6 to 12 in. thick laid on slopes of 1 to 2, 1 to 2½ and 1 to 3 and is covered with spawls or quarry chips.

The superstructure is made with two lines of trusses, 18 ft. 6 in. apart on centers, with top and bottom lateral X-bracing and transverse sway bracing at every top-chord panel point. All trusses have pin-connected tension members and riveted-connected compression members and are about 4 ft. 3 in. apart longitudinally between end pins of adjacent trusses on the piers. The swing span is 445 ft. 6 in. long from center to center of end pins. Each of its trusses virtually consists of two unsymmetrical trusses 213½ ft. long, with pin-bearings at one end on the fixed pier and at the other end on a rectangular system of double plate girders which take bearing at four equidistant points on the turn-table drums 24 ft. in diameter. As the height of the turn-table was not unduly restricted, a very simple construction sufficed for the support of the trusses with the top of the rail 18 ft. above the masonry of the pivot pier.

Traveler Suspended from Main Span.

The trusses are connected together over the pivot pier by an 18½ x 18½-ft. rectangular tower with four vertical posts 72 ft. high connected by three panels of longitudinal and two panels of transverse bracing and having the upper ends of the columns connected to the hip joints of the trusses with four 8 x 1¾-in. eye-bars in each panel. The top chord is made with pairs of built channels, 24 in. deep, latticed on top and bottom flanges; and the bottom chord is of similar construction, 22 in. deep. All vertical and inclined members, except the eye-bars to the hip joints, are made with pairs of rolled or built channels with the flanges turned in and latticed.

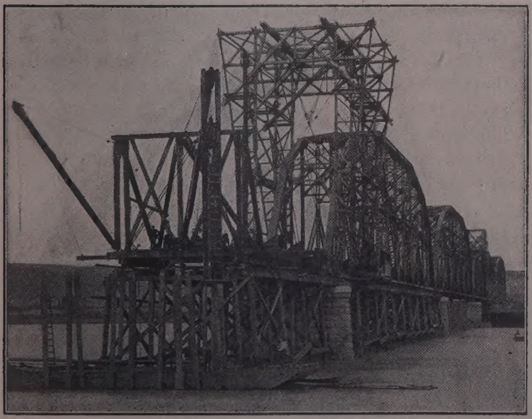
All connections are riveted except for the end bearings and for the eye-bars, which are pin-connected. The ends of the floor beams are notched to clear the bottom chords and their webs project above the top flanges to afford deep connections to the vertical posts. The maximum top and bottom chord cross-sections are about 72 and 79 sq. in. respectively and the tower posts have a total load of about 314,000 lb. each with about 26 sq. in. cross section. The floor beams 36 ft. 6 in. apart and 60 in. deep have ½-in. webs and 6 x 4-in. flange angles reinforced with 9 x ¾-in. cover plates proportioned for a total flange stress of 275,300 lb. The two lines of stringers are 48 in. deep with 7/16-in. webs and 6 x 6 x 13/16-in. flange angles proportioned for a maximum stress of 286,300 lb.

The drum is made with a 60 x ½-in. web and 6 x 4 x ¾-in. flange angles and is braced with sixteen radial girders having 59 x ½-in. webs and 5 x 3½ x ⅜-in. flange angles. Each of the four distributing girders has two 56 x ⅝-in. web plates and a flange with 38 sq. in. cross section made up with two 8 x 8-in. angles and two 9 x 11/16-in. cover plates, for a maximum stress of 544,100 lb. The estimated weight of the span is 1,701,000 lb., including drum, girders, end lift, and so forth.

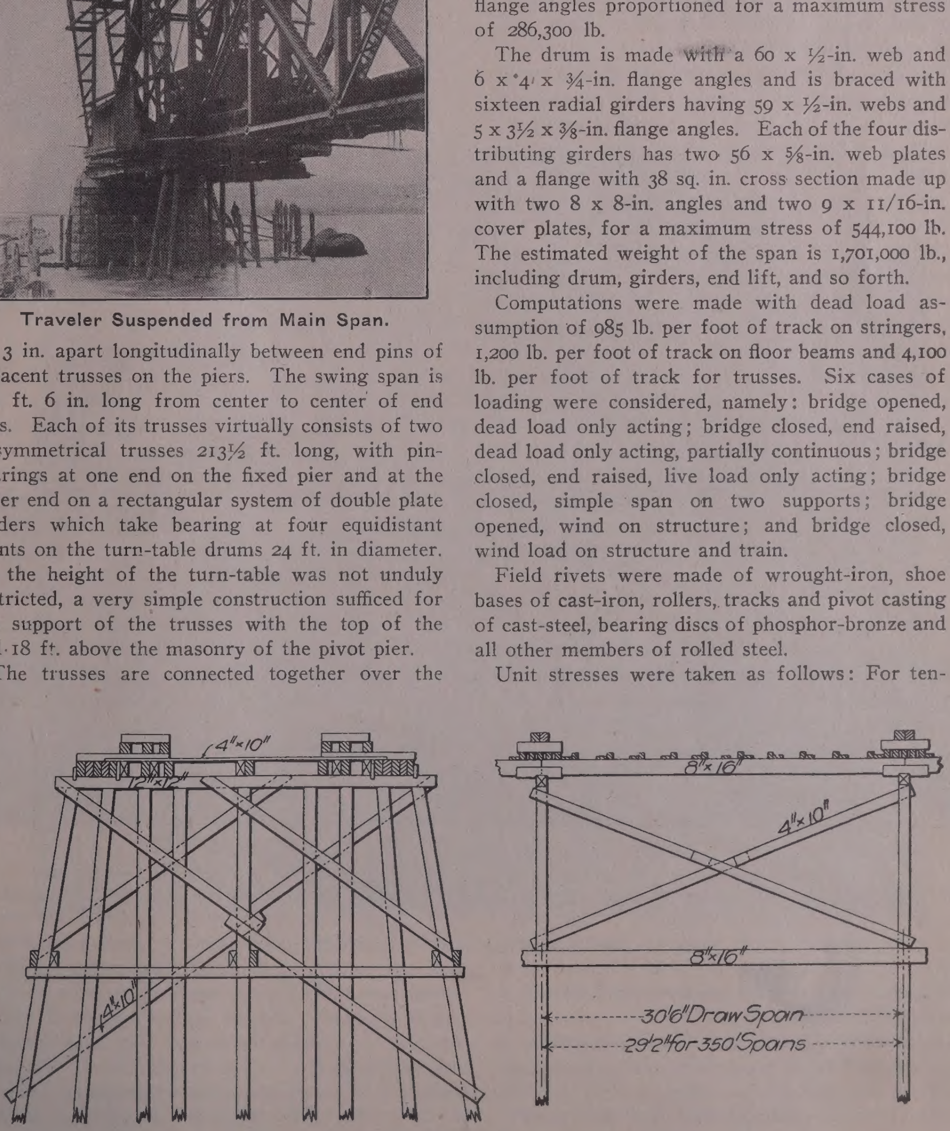
Computations were made with dead load assumption of 985 lb. per foot of track on stringers, 1,200 lb. per foot of track on floor beams and 4,100 lb. per foot of track for trusses. Six cases of loading were considered, namely: bridge opened, dead load only acting; bridge closed, end raised, dead load only acting, partially continuous; bridge closed, end raised, live load only acting; bridge closed, simple span on two supports; bridge opened, wind on structure; and bridge closed, wind load on structure and train.

Field rivets were made of wrought-iron, shoe bases of cast-iron, rollers, tracks and pivot casting of cast-steel, bearing discs of phosphor-bronze and all other members of rolled steel.

Unit stresses were taken as follows: For ten-



Main Spans, Falsework and Traveler.



Typical Falsework Bent, Missouri River Bridge.

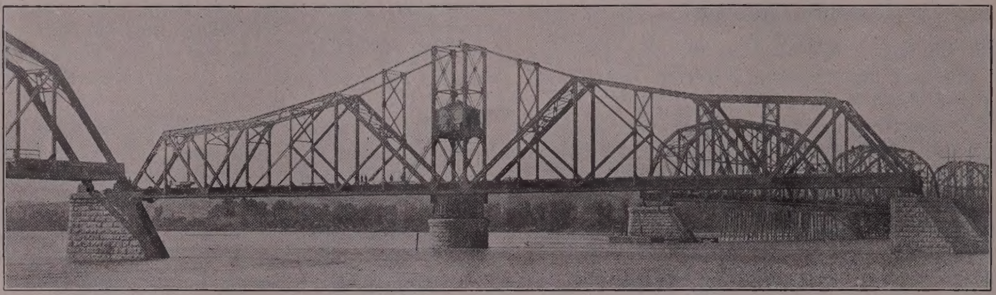
sion, in structural steel, 15,000 lb., eye-bars and pins, 17,000 lb. For compression, in structural steel, $P = 15{,}000 \div (L^2 \div 1 + 13{,}500 R^2)$, where P equals permissible working stress per square inch, L equals length of piece in inches and R equals least radius of gyration in inches. Bearing for pins 22,000 lb., bearing for shop rivets 22,000 lb., bearing for field rivets 17,500 lb., shearing for pins and shop rivets 11,000 lb., for field rivets 8,800 lb., for web plates 9,000 lb. Coopers class E-50 live load was assumed and impact was provided for by the formula $I = L^2 \div (L + D)$, where I equals amount to be added for impact, L equals live load and D equals dead load. It was required that all field connection rivet holes for floor beams, stringers and loading girders should be accurately reamed to cast-iron templates and all shop work and details were in accordance with the standard specifications of the Chicago & Northwestern Ry.

The four duplicate fixed spans are 58½ ft. deep at the center and 36 ft. deep at the hips and have an estimated total weight of 1,342,000 lb. each. They are made with panels 29 ft. 2 in. long, having floor beams and stringers substantially like those of the draw span. The top chords and end posts are made with three 30-in. webs, 30-in. cover plates and four 4 x 4-in. top flange and four 6 x 4-in. bottom flange angles. They have a maximum stress of 1,632,000 lb., and cross sectional area of 120 sq. in. gross, which although theoretically slightly less than the 121.6 sq. in. required for the unit stress of 13,450 lb., is in reality fully provided for by the excess thickness caused by overrunning the ordered weight. The maximum bottom chord stress of 2,165,000 lb. divided by 21,000 lb. unit stress gives 103 sq. in. sectional area which is provided almost exactly by two 9 x 1⅞-in. and four 9 x 1 15/16-in. eyebars.

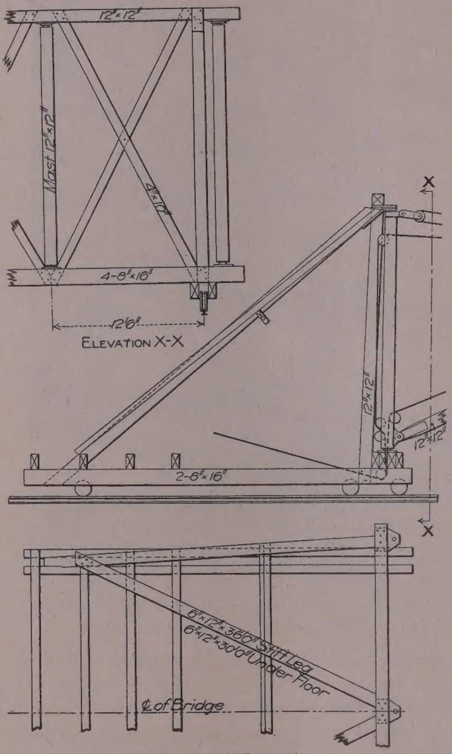
The top and bottom lateral diagonals are made with pairs and double pairs of angles riveted and made ⅛ in. shorter than the calculated length to provide for inital tension. The spans were assembled with an erection cambre of 4 3/16 in. A special feature of the fixed spans is the provision of sliding bearings for one end of the stringers in the fourth panel from each end, which are intended to reduce the transverse bending stresses in the floor beams. The drawbridge is provided with toggle devices for lifting the ends and is operated by a 40-h.p. Otto gasoline engine.

The entire superstructure was erected on pile falsework about 25 ft. high above low-water level and the trusses were assembled by a three-bent wooden gantry traveler of the usual type. The intermediate falsework bents, at panel points of the trusses, were made as indicated in the elevation with seven vertical and two battered piles capped with a single 12 x 12-in. horizontal timber drift bolted to them and receiving the 15 lines of 8 x 16-in. stringers directly without the interposition of framed bents. Transverse planks 4 in. thick and 24 ft. long were spliced across the tops of the stringers to serve as ties for the material track between them and the traveler track and the cambre blocking were laid on 6 x 8-in. ties 8 ft. long on each side of the center line engaging the eight rows of stringers there. The piles were from 50 to 60 ft. long and all connections were made with ¾-in. bolts and cast-iron washers.

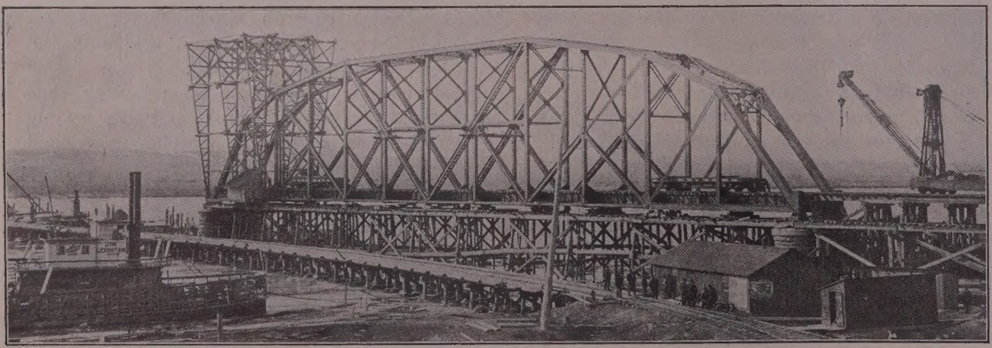
The falsework piles for the first six spans were driven by a 7,800-lb. No. 1 Vulcan steam hammer suspended from the 30-ton, 40-ft. boom of a movable stiff-leg derrick 30 ft. high. For the remaining spans the falsework piles were driven by a special traveler with a horizontal platform 32 ft. long and 25 ft. wide, equipped on the forward end with three stiff-leg derricks having 12 x 12-in. masts 20 ft. high. The booms for the center and side derricks were 45 ft. and 40 ft. long, respectively, and the former was fitted with leads for the steam hammer. The side booms unloaded piles from a car in the rear and placed them in the leads and assembled the other timber in the trestle. The traveler was provided with six double-flange wheels engaging the 25-ft. gauge tracks of the main traveler and was equipped with a double drum four-spool hoisting engine operating the derricks. The special traveler was of very simple construction and proved very efficient and satisfactory, being pronounced by the resident engineer "the best thing of the kind he ever saw."



Completed Swing Span of Missouri River Bridge, October 13, 1907.



Falsework Traveler.



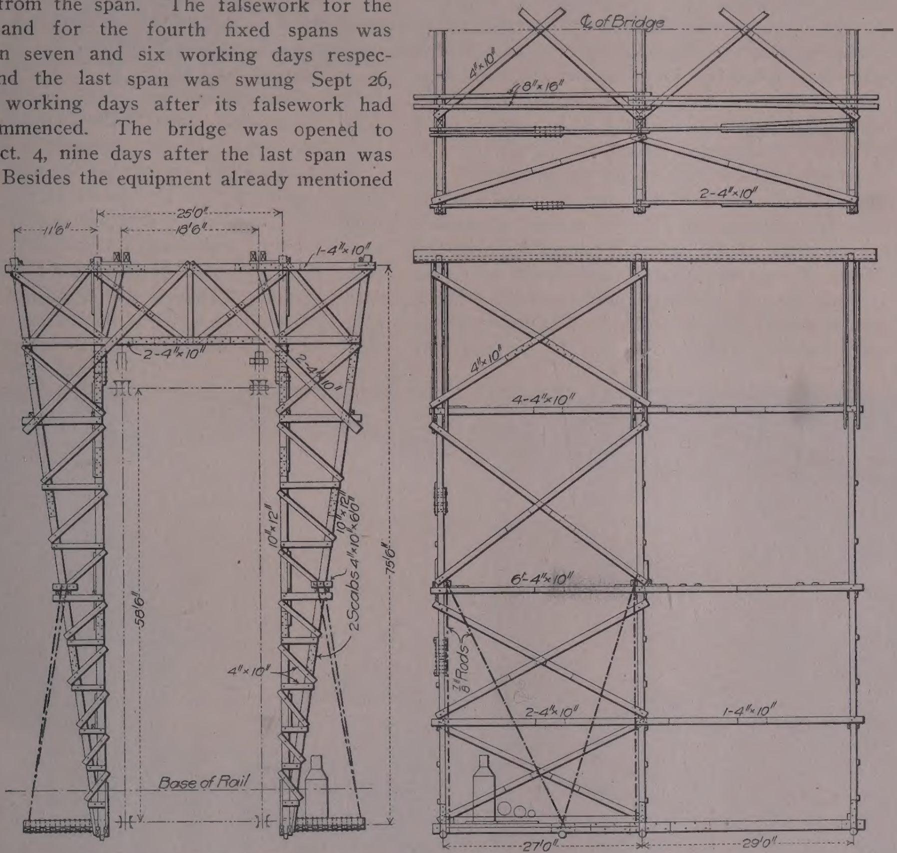
Fixed Spans on Falsework, March 4, 1907.

The main traveler, about 80 ft. high and 58 ft. long over all, had a vertical and horizontal clearance of about 66 and 23 ft., respectively, and was mounted on six solid double-flange wheels 20 in. in diameter, with fixed axles 2½ in. in diameter and 14 in. long. The traveler was provided with double 8 x 16-in. jigger beams in the planes of the trusses, and had an 11 x 26-ft. engine platform suspended outside the vertical posts on both sides of the traveler just clear of the falsework. This platform was supported at the ends and at the center by pairs of ⅞-in. vertical and inclined tie rods and was peculiar in that the 8 x 16-in. longitudinal floor timbers were bolted to the under side of the transverse timbers supporting them. It was equipped with two 8 x 12-in. double-drum hoisting engines and cleared all parts of the superstructure, except the center panel or tower of the draw span, the upper part of which was erected by a gin pole after the traveler had passed. In order to provide against the possible loss of the falsework, after the superstructure was swung and before the traveler was removed, the latter was provided with bearings by which it might be supported from the span in case the falsework was lost, a provision which proved necessary and successful twice during the erection of the bridge.

The construction of the falsework for the first span was commenced January 11, 1907, and was completed Feb. 8 following. The pile driver was followed by a small derrick car with a 20-ton, 40-ft. boom by which the floor beams and stringers were assembled in position as the falsework advanced. The erection of the main traveler was commenced Feb. 11, and was finished Feb. 16, after which the high water threatened to carry off the ice and the structure was considered to be in such danger that on Feb. 19 and 20 the floor beams and stringers were removed. On Feb. 22, the danger having diminished, the work of replacing them was commenced and the span was erected and swung on March 1. Three days later the river was so threatening that the traveler was hung from the span and was thus saved when on March 7 the falsework from which the decking had been removed was carried out by the ice.

Transverse beams were swung under the traveler track stringers and suspended from the lower chord panel points. They were adjusted to bearing against the stringers and released the falsework bents so that the removal of the latter did not affect the safety of the traveler. The accompanying illustration shows the traveler thus suspended from the end of the span after the ice had moved out. There was not time to pull all the piles and those seen under the traveler are entirely clear and independent of its track.

The falsework for the swing span was commenced April 9, and was partly carried away April 12. Work on it was resumed April 20, and completed May 7, and the floor system assembled with the derrick car as previously described. The lower track of the turn-table was commenced May 3 and the span was completed May 25. On May 27, the falsework was partly carried out by flood and drift but the traveler being supported on the middle of span 3-4 was saved and later moved to pier 4, on supports suspended from the span. The falsework for the second and for the fourth fixed spans was driven in seven and six working days respectively and the last span was swung Sept 26, thirteen working days after its falsework had been commenced. The bridge was opened to traffic Oct. 4, nine days after the last span was swung. Besides the equipment already mentioned the erection plant included one Davenport dinky locomotive and two Ingersoll-Sargent air compressors operated by two belt-connected 15-h.p. Otto gasoline engines.



Traveler for Erecting Main Spans of the Missouri River Bridge.

The Missouri River, always treacherous, was more dangerous than usual for bridge erection during the season of 1906 and 1907, when this bridge was erected and the water was a great deal higher than usual during the winter and broke up carrying the ice out much earlier in the Spring than ever previously recorded. Notwithstanding these conditions, which were fully provided for in the plans and arrangements for erection, the bridge was constructed safely and quickly without serious loss and in a manner which reflects credit on the engineers and contractors in charge.

The work was carried out under the general direction of Mr. E. C. Carter, chief engineer of the Chicago & Northwestern Ry. Co., Mr. W. H. Finley, assistant chief engineer, had general direction of the work in the field and in the office. Mr. F. H. Bainbridge was engineer in charge of the work at Pierre and the plans were prepared in the main office under Mr. I. F. Stern, engineer of bridges. The contract for fabrication and erection was awarded to the Pennsylvania Steel Co., who sublet the erection to the Bernhisel Construction Co., Evanston, Ill. The piers were built by Mr. A. MacMullen and the grading was done by Mr. H. N. Betz.

A GAS HOLDER with a capacity of 10,000,000 cu. ft., to be built at Manchester, England, is one of the largest and heaviest of its type that has been undertaken. The outer shell or lift is to be 282 ft. in diameter and each of the four lifts 42.5 ft. deep. The guide framing will consist of 32 latticed steel standards, 168 ft. high, and connected by six tiers of latticed steel girders.

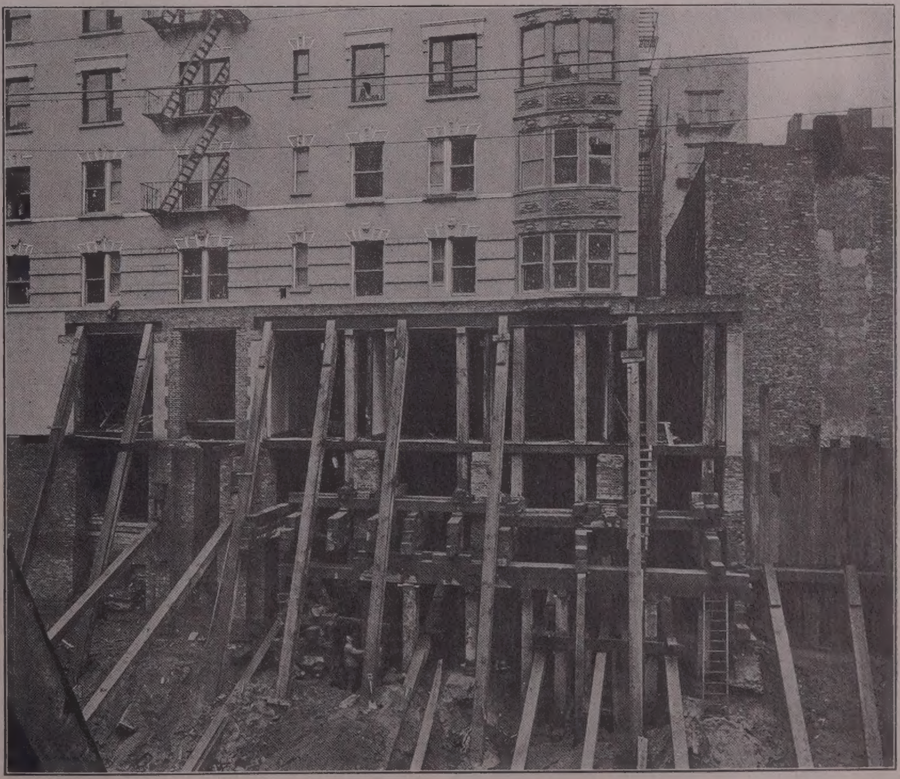
Underpinning Six-Story Apartment Houses in New York City.

The four-track reinforced concrete structure of the bridge-loop subway which is under construction to connect the Brooklyn, Manhattan and Williamsburg bridges over the East River in New York, crosses the block between Mott and Elizabeth Sts., about midway between Spring and Broome Sts., in the new Delancey St. extension, from which all buildings have been removed, enabling the subway to be built in an open cut about 42 ft. in depth and of practically the full width of the street. The excavation is in fine, dry sharp sand, retained on the sides of the trench by 2-in. square-edged sheet piling driven with mauls as the excavation is made. On each side of Delancey St. there is a six-story and basement apartment and store house, one at No. 184 on the west side and the other at No. 190 on the east side of Mott St., which are about 100 ft. deep, extending back toward Elizabeth St.

The front walls of the buildings are carried on brick piers from about 5 to 15 ft. wide in the first story, which piers are seated on continuous foundation walls 30 in. thick at the basement floor, with concrete footings, 4½ ft. wide, seated on the dry sand about 12 ft. below the basement floor, or 21 ft. below street level. As the subway excavation adjacent to these footings is about 22 ft. deeper it could not be made without danger of undermining the walls until the latter were supported on new footings carried down below subgrade. They were accordingly supported temporarily on needle beams and underpinned with massive concrete foundations constructed at a considerable expense as described in this article.

The buildings have been very recently completed, and not yet being occupied access was readily obtained to them and the work was carried on without restrictions in their basements. The same methods were pursued for the buildings on both sides of the subway, and their walls were supported and underpinned in successive short sections from rear to front in a manner corresponding throughout with that used for a single wide pier at the west end of the south wall of 190 Mott St., as shown in one of the accompanying illustrations.

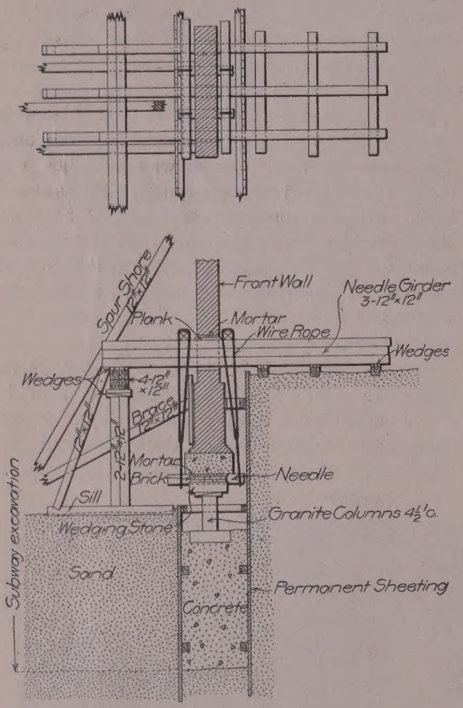
Rectangular openings about 5 ft. apart on centers were cut through the basement wall just above floor level, and in them were inserted compound needle beams, each made with three 12 x 12-in. timbers about 34 ft. long, supported in the basement on three 12 x 12-in. sills parallel with the wall. The outer ends of the needles were supported on a continuous girder made with four 12 x 12-in. beams, with a bearing under each needle beam on a pair of 12 x 12-in. vertical timbers, having their lower ends seated on timber sills just below the bottoms of the original footing



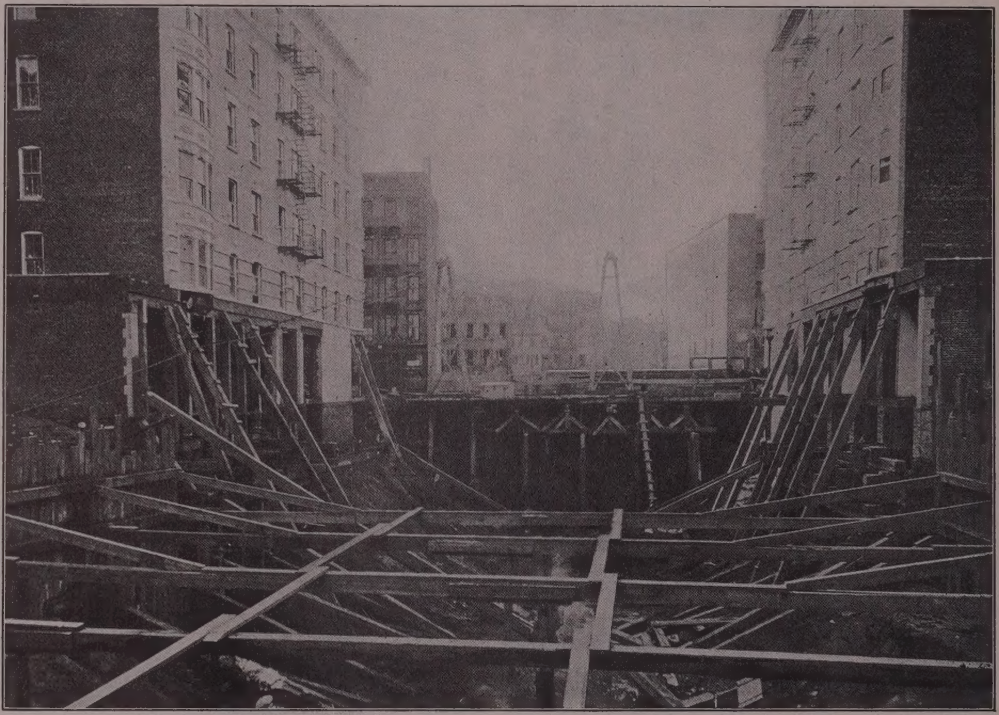
Needle Beams and Bracing for Six-Story Wall.

at the maximum depth to which the excavation could be safely made before underpinning was commenced.

Portland cement mortar spread on the upper sides of bearing planks was inserted through the openings in the walls over each needle beam, providing, when it hardened, a uniform bearing on the needle for the brick work and was forced up into contact with the latter by adjusting the needles with wedges between them and the longitudinal sills while the mortar was still soft. The outer ends of the needles projected beyond the longitudinal girders and were additionally supported and braced by battered posts in the planes of the vertical posts. Between the vertical posts inclined 12 x 12-in. shores were placed, with bearings on the face of the wall at about the second-floor level and just below the first-floor level, engaging at the latter place vertical rangers to distribute the pressure over horizontal face planks covering the front of the brickwork. The wall was thus sufficiently secured to permit the excavation of a sheeted trench about 8 ft. wide on its center line. As soon as this trench reached the bottom of the old footings small tunnels were drifted under them and 12 x 12-in. timbers inserted and suspended from the needle beams above by double pairs of 1-in. wire rope, with turnbuckle adjustments, permitting them to be placed under considerable initial tension before the excavation was carried deeper, so as to undermine the old footings and throw the entire weight of the wall below the basement floor on them.



Support of Wall over New Footing.



Underpinning Houses on Both Sides of Delancey Street.

The trench was carried down to a total depth of about 28 ft. below the basement floor, or just to ground water, from which point five 8-in. wrought iron pipes were driven 1 ft. below subgrade, scooped out and filled with concrete. About 1 ft. of the pipe was left projecting, and around it concrete was deposited and carried up to the underside of the piers, which were alternately carried on 20-in., 80-lb. I-beams about 18 ft. apart. As the excavation of the trench progressed sections of it from 10 to 20 ft. long were enclosed by transverse bulkheads and were filled with 1:3:5 Edison Portland cement up to a height of about 16 ft. from the bottom, the sheet piles serving as forms, permanent on the inside and detachable outside, after the subway excavation should be compelted. Granite blocks 4 ft. square and 14 in. thick were bedded horizontally in the concrete, with their dressed upper surfaces flush with the top of the concrete, and on them were set, about 4½ ft. apart, vertical granite columns 15 in. square and 3 ft. long, on the center line of the wall. Both ends of these columns were very carefully dressed square; the upper end was covered with pairs of thin, narrow steel wedges, affording bearing for 4 x 4-ft. granite cap stones, 14 in. thick, which were bedded horizontally in the concrete, with their dressed upper surfaces flush with the top of the concrete, and on them were set, about 4½ ft. apart, on the center line of the wall, vertical granite columns, 15 in. square and 3 ft. long. Both ends of these columns were very carefully dressed square, and the upper end was covered with pairs of thin, narrow steel wedges, affording bearing for 4 x 4-ft. granite cap stones, 15 in. thick, with carefully dressed horizontal faces. Forms were placed, and all the space between them and the lower surfaces of the original concrete footings was grouted. The needle beams were released, and access to the wedges was maintained for several days longer, during which time they were driven a little from time to time to compensate for any settlement or compression caused by the load of about three tons per square foot on the sand in the bottom of the trench. A vertical displacement of about ⅛ to ¼ in. was thus cared for in four or five days, after which no further movement was observed, and at the end of ten days or more the trench was filled with concrete up to the old footings, enclosing the granite columns and steel wedges.

The underpinning involved about 200 linear feet of wall, and required 600 cu. yd. of concrete. Careful levels were taken on the building before operations were commenced, and observations were made daily, which showed that few settlements or cracks were occasioned by the work. The underpinning, including the excavation for the supports of the needle beams, the shoring and the adjustment of the inclined braces, was accomplished in about 140 working days by a force varying from 12 to 20 men.

The work was done subject to the approval of the Public Service Commission. Mr. Henry B. Seaman, chief engineer; Mr. Geo. S. Rice, engineer of subways, and Mr. G. H. Clark, division engineer. The details of the work were designed and it was executed by the contractor for this section of the subway, the Bradley Construction Co., Mr. Bayly Hipkins, chief engineer, and Mr. T. P. Galligan, superintendent.

A New Method of Measuring Extension in Tension Tests.

A paper by Wesley J. Lambert, reprinted from the Minutes of the Proceedings of the Institution of Civil Engineers.

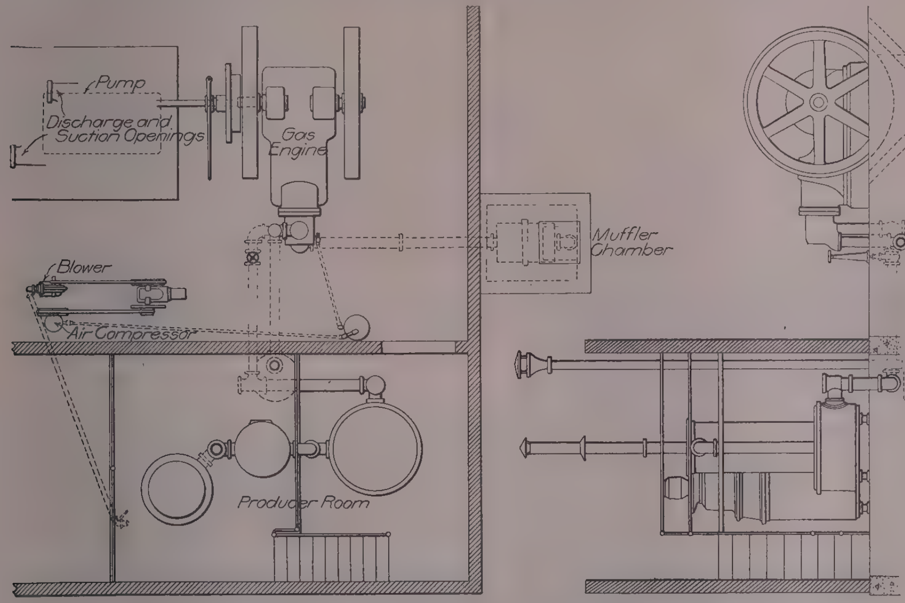
Having occasion recently to determine the modulus of elasticity of a special steel, and a mechanical extensometer of sufficient delicacy not being immediately available, it was suggested to the author by Col. H. C. L. Holden that an optical method of measuring the extensions might be devised. The method described in the following paper is the outcome of this suggestion.

Briefly described, the method consists of measuring upon a screen the optically-projected magnified image of the gap produced by the separation of two knife-edges fastened to the test-piece, the method of projecting the image being in all respects similar to that employed in microphotography. A source of light being placed behind the knife-edges, the gap is magnified under a microscope having a projecting eye-piece and camera-extension, in such a manner that the degree of magnification may be readily ascertained.

The test-pieces used in the determinations were ordinary tensile specimens with screwed ends, 10 in. in length between the shoulders, and 0.564 in. in diameter, which gives a cross-sectional area of ¼ sq. in. They were accurately ground between centers, and each specimen was critically tested for parallelism and straightness both before and after loading.

Fastened to the shoulder at each end of the specimen was a strip of steel plate terminating in a detachable knife-edge, the two knife-edges being immediately opposite each other, in the same plane, and on one side of the steel strips. One of the knife-edges is adjustable by means of a screw and slotted hole. This arrangement of detachable knife-edges facilitates the final adjustment of the edges. The two fastening-screws, being held lightly against the test-piece by small elastic bands slipped over the strips and the specimen, also serve as distance-pieces to keep the strips parallel to the test-piece. The method of fastening a strip upon the shoulder of the test-piece is by springing the end, which is bent in circular form, over the shoulder and securing it by soft solder. By means of fine lines scribed upon the strip and shoulder, it was possible, by subsequent examination, to be assured that no alteration in their relative positions had taken place. This mode of attachment was found to be simple and effective.

The microphotographic outfit consisted of the ordinary apparatus used in a metallurgical laboratory. The microscope, for convenience, was detached from its stand and was held in a special clip which allowed of adjustment in any direction. Upon the screen (a piece of very finely ground glass), at the rear end of the camera, a sliding vernier was fixed, which enabled the width of the image of the gap to be measured with great accuracy. The magnification was determined by placing a millimeter stage-micrometer exactly in the position occupied by the knife-edges, and comparing the measurements by means of the vernier on the screen, thus ascertaining the extension of the camera necessary to obtain the required magnification.



Arrangement of Gas-Producer Pumping Installation.

The actual magnification employed was 100 diameters; thus a gap of 0.005 in. was magnified to ½ in., read off by means of the vernier to thousandths of an inch.

The mode of procedure in making a test is extremely simple. The test-piece having been placed in position in the testing-machine, with the knife-edges properly adjusted, the source of light is focussed on the back of the knife-edges, the gap is carefully focussed upon the screen, and the width of its image is measured by means of the vernier. A known load is then applied, and the width of the image of the gap is again measured. The difference of the two readings gives the extension due to the load applied. This process having been repeated for a series of increasing loads, readings are obtained which enable a stress-strain diagram to be plotted, and the modulus of elasticity of the test-piece to be determined.

By substituting for the screen a photographic plate contained in a dark-slide a photograph of the image of the gap may be obtained.

By the combination of the microscope, camera and vernier, the extensions can be measured accurately to 0.00001 in. with comparative ease.

The advantages of the method are: 1, simplicity; 2, the entire absence of mechanical contrivances attached to and working from the specimen; 3, the extreme accuracy with which the extension can be measured; and 4, the facility with which photographic records may be secured of the extensions resulting from varying loads.

A Single-Phase Locomotive consisting of two cars, each with two axles, is being tested by the Prussian State Railways. The locomotive weighs 59.5 tons, and is equipped with three motors developing 250 h.p. each at 500 r.p.m.

The Suction Gas-Producer Pumping Plant at Westford, Mass.

The Westford Water Co. was organized in March, 1907, to supply water for domestic consumption and fire protection in the three villages of Westford Centre, Graniteville and Forge Village, all in the Town of Westford, Middlesex County, Mass. The company's plant comprises 8.16 miles of cast-iron and wrought-iron mains, 42 Matthews fire hydrants, two steel standpipes for the high and low services, and a suction gas producer pumping plant located at Pine Ridge, and cost approximately $80,000. The source of supply is from 2½-in. tubular wells, located near the edge of the meadows leading down to Stony Brook, which tap a coarse water-bearing gravel stratum with a very extensive underground watershed running back from the meadows with the same gravelly nature. The supply has been pronounced practically unlimited so far as the future demands of the district to be ultimately supplied are concerned, and repeated analyses of the quality of the water place it among the finest waters of the State.

Interior of Engine Room of Pumping Plant.

The average depth of the wells from the surface of the ground to the top strainer hole is 25.5 ft. The yield of ten of the wells in the preliminary tests with a No. 3 Edson diaphragm pump was at the rate of 406 gal. per minute, the individual yields running as high as 53 gal. per minute. The suction main, increasing from 6 to 8 in. in size, is fitted with a Smith sand chamber just outside the pumping station. The building is of wooden frame, simple mill type with tar and gravel roof. It sets in a side hill for easy handling of coal, and is carried on heavy concrete retaining walls on one side.

The engine room is laid out 30 ft. by 21 ft. 10 in., and the producer room 12 ft. 8 in. by 30 ft. In the latter room is an elevated coaling platform on a level with the coal bin outside of the building. Into this platform is set a Fairbanks platform scale for weighing coal. All suction and discharge pipes and drains are carried in concrete trenches. The force main branches inside the building to supply the high and low service systems and is fitted inside the building with a pumping-to-waste branch, check valve and controlling gates and outside the building with a cross connection between the high and low services with a controlling gate. Four 15-in., 42-lb. I-beams span the engine room so that any casting can be easily handled.

The pumping plant consists of the following parts:

First. One type K, four-cycle, horizontal single-cylinder, throttle-governed, heavy-duty Olds gas engine, with a normal capacity of 50 brake horse-power at 240 r.p.m. The speed is controlled by a centrifugal governor acting on the common air and gas valve, positively driven by spiral gears from the lay shaft of the engine. Regulation is accomplished by throttling this governor, thus varying the proportion of explosive mixture admitted to the cylinder in proportion to the load on the engine. The fly wheels are two in number, 96 in. in diameter and weigh 3,700 lb. each. A low-tension make-and-break magneto is used and the igniter is located centrally in the combustion chamber. The cylinder, its head, the valve chamber and a part of the exhaust piping are water cooled. The piston is oiled with a sight-feed high-pressure oil pump, the main and lay shaft bearings with adjustable sight-feed oilers and the crank pin by a centrifugal oil ring fastened to the crank cheek and fed from a sight feed oiler. The spiral gears are enclosed in oil-tight casings. There is an air compressor for starting, driven by a small independent gasoline engine.

Second. One type A Pintsch suction gas producer designed for use with pea anthracite coal, with a normal capacity of from 40 to 60 h.p. It consists of a generator 5 ft. 1½ in. high by 40 in. in diameter lined with fire brick, the space between the brick and shell being filled with mineral wool. The ash-pit is provided with four self-sealing, ground-joint cleaning doors and there is a double-closing hopper of the shot-pouch type for feeding coal. The grates are specially designed for pea anthracite coal. The vaporizer is superimposed. The scrubber is 8 ft. 6 in. high by 32 in. in diameter and is fitted with a removable water sprinkler, cleaning doors and hand hole. The cleaner is 26 in. high by 54 in. in diameter, with two wooden trays covered with 2 in. of shavings resting on a coarse-mesh burlap. There is a small power blower operated by the independent gasoline engine. This gasoline engine, compressor and blower are located in the engine room, and the partition wall between the engine room and the producer is as nearly dust proof as possible, and is fitted with a small window so that the engineer, standing at the producer, can watch the engine governor.

Third. One 8 x 12-in. class B, heavy-type, vertical triplex four-standard Smith-Vaile pump, having a calculated capacity of 310 U. S. gal. per minute at 44 r.p.m. against a maximum pressure of 200 lb. per square inch.

With the standpipes full, the pressure on the high-service gauge at the station is 158 lb. per square inch, and on the low-service gauge 92 lb. per square inch. The high-service force main is 6 in. in diameter and 8,611 ft. long, while the low-service force main is 8 in. in diameter and 5,850 ft. long.

Two carefully-conducted tests have already been made of this plant, one of 6 hours 12 minutes duration, about the normal pumping period, on Feb. 27, and one 24-hour continuous run on March 9 and 10. In the first test, assistance was given by a corps of senior students in mechanical engineering under Professor Lionel S. Marks, of the Lawrence Scientific School, Harvard University.

Table Showing Results of Two Tests.

	First Test.	Second Test.
Time	6 hr. 12 m.	24 h.
Total revolutions	13,171	51,539
Discharge per revolution, deducting 1 per cent. for slip, cu. ft.	1.0367	1.0367
Temp. of discharge water	48°	48°
Total water discharged, lb.	852,219	3,334,787
Equivalent total lift, ft.	404.6	416.21
Horse-power, pump end	28.08	29.21
Horse-power hours, pump end	174.096	701.04
Total coal used, lb.	271.75	960
Coal per h.-p.-hr., pump end, lb.	1.56	1.37
Average ind. h.-p.	34.3	...
Pump efficiency, per cent.	81.8	...

The composition of the coal by weight was as follows: Moisture, 3.1 per cent.; volatile gases, 9.1 per cent.; fixed carbon, 75.8 per cent.; ash, 12.0 per cent. The composition of the producer gas by volume was 9.2 per cent. of hydrogen, 2.1 of light hydro-carbons, 19.13 of carbon monoxide, 5.8 of carbon dioxide, 1.1 of oxygen and 62.67 of nitrogen.

Pea anthracite costing 26 cents per 100 lb. delivered at the station was used. For the second test the cost of fuel was $2.50, of the gasoline and lubricating oil was $1.05, of the attendance was $7.75, and of the water was 50 cents, making the total station expenses chargeable to the run $11.81, or 7.2 cents per million gallons raised 1 ft. high.

The company was organized and its works designed and constructed by Mr. Edmund M. Blake, of Boston, who was recently re-elected its president and appointed general manager. The company has a contract with the Town of Westford for fire protection service for ten years, starting on the basis of forty hydrants at $40 each, with the privilege of adding as many more at this rate as may be desired.

Cost Data on Concrete Lining in Gunnison Tunnel.

The Gunnison Tunnel being constructed by the Reclamation Service near Montrose, Colorado, is the largest work of its character and purpose. This tunnel has a width of about 11 ft., a height of 12 ft. and will have a length of 31,000 ft. when completed. The total cross sectional area is 123 sq. ft., the excavated volume therefore being 140,000 cu. yd. The tunnel will have a carrying capacity of 1,300 second feet and will divert water for irrigation purposes from the Gunnison River into the Uncompahgre Valley through a divide having an elevation of about 2,000 ft. above the tunnel grade. Mr. F. W. Hanna, engineer, U. S. Reclamation Service, has compiled data on the cost of the concrete lining in this tunnel from a report by Mr. E. L. Driggs, junior engineer of the Reclamation Service stationed at Montrose, Colorado.

Suction Gas Producer.

A portion of the tunnel was driven through soft material, but the great majority thereof has been, and is being excavated in granite. At the present time in addition to about 4,000 linear feet of under-cut drift there have been about 21,000 linear feet of the excavation of the tunnel completed, about 8,500 ft. of which have been lined. The lining of the side walls and arch is being placed in one of the headings by means of a special traveling device, figures on the cost of which are given in an accompanying table.

Table Showing Cost of Concrete Tunnel Lining.

Distribution of Cost.	Total cost.	Cost per lin ft.	Cost per cu.yd.
Superintendence	$187.50	$0.203	$0.212
Placing forms	275.12	0.336	0.351
Tearing down forms	288.80	0.307	0.321
Mixing concrete	305.52	0.331	0.345
Placing concrete	583.6[illegible]	0.632	0.659
Hauling concrete	218.02	0.236	0.246
Sand and gravel	793.70	0.859	0.897
Cement	3319.15	3.592	3.750
Totals	$5,971.49	$6.496	$6.781

This traveler consists of a large frame, end views of which are in the form of the letter H. Beneath these end frames are wheels rolling over a temporary movable track placed outside of the construction track of the tunnel. Between the crosses of the H's and resting thereon is a platform equipped with a track having a gauge equal to that of the main tunnel track, boxes on each side of this track and a hoisting engine at one end. The elevation of this platform is approximately 6 ft. above the main tunnel track, and the entire length of the platform is about 20 ft.

Cars containing the concrete mixed and ready for placing are run in on the main tunnel track beneath the hoisting apparatus on the traveler. They are then elevated by means of the hoisting engine to the platform above referred to, on which they are moved about. The concrete is dumped from the cars into the boxes on the platform on the sides of the track. From these boxes it is shoveled directly into the arch or walls of the tunnel lining. The elevation of the platform and the design of the entire placing apparatus are such that the transportation of the debris from the heading is not interfered with, the cars and electric trams being able to pass beneath the traveler.

The organization of the operating gang consisted of one foreman, one motorman running the tram from the mixer to the point of placing, one brakeman operating in connection with the train and running the hoisting engine on the traveler, three men mixing the concrete, two men placing the forms, two men tearing them down and six men shoveling the concrete. While the cars were being hoisted, the two men that were placing forms or the two that were tearing them down, or one of each, depending on the amount of work that each gang had to do, uncoupled the cars and ran them onto the hoisting cage.

In placing the lining the arch and walls were carried along practically continuously, as the length of the traveler made it impossible to carry the walls more than about 15 to 20 ft. ahead of the arch. The advantage of this method over the ordinary hand method consisted in the use of electric power for lifting the concrete into the lining. The disadvantage lay in the fact that the arch could not be carried along but from one point. It also required approximately from 45 minutes to one hour each day to move the traveler forward.

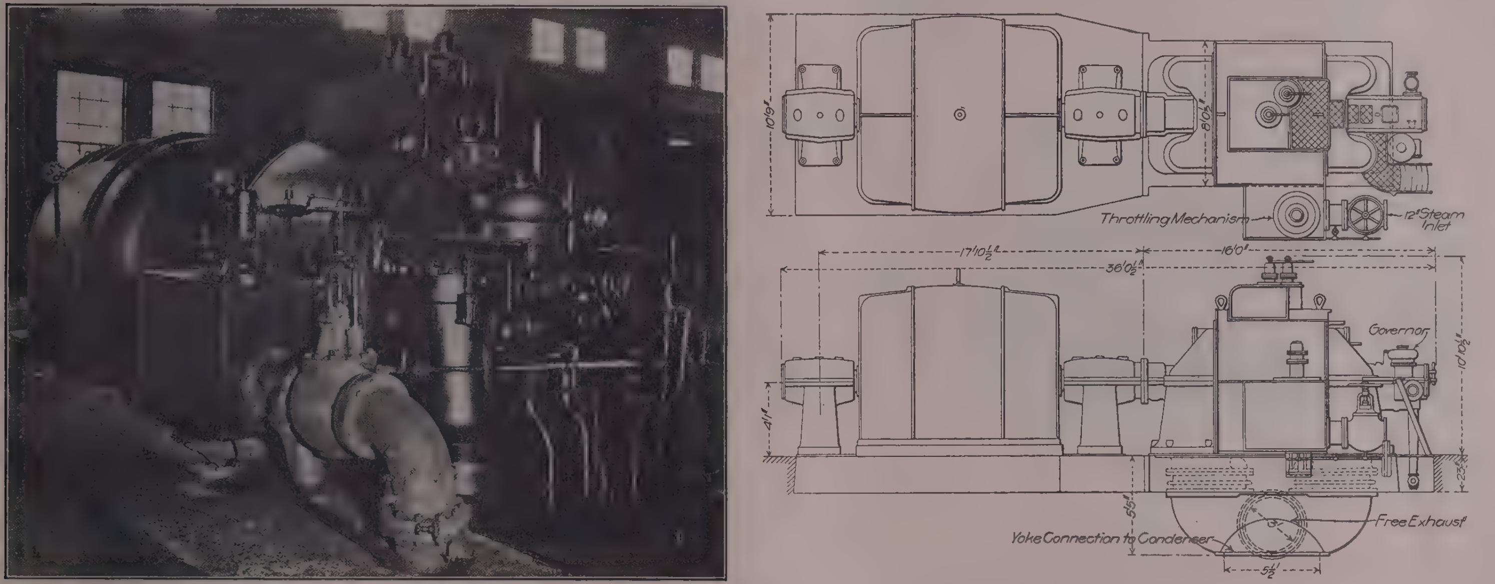
The accompanying cost data cover the lining placed with the traveler during October and November, 1907. During the period in question 818 linear feet of forms were put into place and 940 linear feet were taken down. Steel forms were used and were comparatively easily removed. The data given relates to the placing of the arch and side walls only and during the time for which these data are given 885 cu. yd. of concrete were placed, lining 984 linear feet of the tunnel, involving the use of 1106.5 barrels of cement and 1246 cu. yd. of sand and gravel. The cement and the aggregates delivered at the mixer cost respectively $3 per barrel and $0.637 per cubic yard.

The total and unit costs in connection with this work, distributed under headings of superintendence, placing forms, tearing down forms, mixing concrete, hauling concrete, placing concrete, sand and gravel, and cement, are given in the table. The foreman was paid at the rate of $5 per day; the men handling the forms and mixing and placing the concrete received $3.04 per day. The motorman received an average of $3.16 per day, and the brakemen an average of $2.91 per day. The mixture of the concrete was in the proportion of 1:2½:5.

An Old Cast-Iron Pipe was uncovered in the excavation for the bridge loop subway in New York which was connected directly with a hollow-log pipe forming part of the water-works of the Manhattan Co. The joint was made by merely driving the end of the iron pipe into the ends of the hollow log. The cast-iron pipe was in good condition, free from serious corrosion and could be used again safely. The joints were made with lead.

The New Double-Flow Turbines at the Brunot Island Power Plant, Pittsburg, Pa.

An unusual opportunity for comparison of the effect of the steam turbine upon power plant development is afforded in the recent increase of capacity of the Brunot Island station of the Pittsburg Railways Co. by the installation of steam turbines of the new double-flow design, recently perfected by the Westinghouse Machine Co. The Brunot Island plant is designed for mixed service, supplying power to street railways in both Pittsburg and Allegheny, and also a large part of the lighting for the same district. Owing to the extraordinary increase in the demand for power, it became necessary to increase the capacity of the plant considerably beyond that for which the original designs were made. In the present power-house room had been provided for three 1,500-kw. cross-compound condensing engine units in addition to those originally installed, but as the extension necessary far exceeded these provisions, steam turbines were adopted for the motive power, with the result that instead of being limited to 4,500 kw., a total of 18,000 kw. additional capacity has been installed, with still sufficient room for an additional turbine. In other words, the space originally provided for 4,500 kw. in engine-driven machinery accommodates 23,000 kw. of turbine machinery.



The New 5000-kw. Double-Flow Turbine at the Brunot Island Power Plant, Pittsburg, Pa.

The original equipment of the station consisted of five 1,500-kw. Rice & Sargent cross-compound condensing engines, three direct connected to 550-volt Westinghouse direct-current railway generators and two to 6,600-volt Westinghouse two-phase alternators, with space left in the engine room for three more similar units. The boiler equipment consisted of 20 Babcock & Wilcox water-tube boilers, each of 500 hp. capacity. For the extension a new boiler house is being erected parallel with the present building and will contain sixteen 400-hp. Babcock & Wilcox water-tube boilers, all equipped with the Westinghouse new model Roney mechanical stokers. The boilers will, like those of the original installation, be arranged in pairs, discharging gases into eight independent stacks, 7 ft. internal diameter and 250 ft. high.

The new turbine equipment consists of one 3,000-kw. and three 5,000-kw. double-flow units, which are arranged axially crosswise of the engine room. The 3,000-kw. unit is in place and has been in operation for nearly one year, while the larger units are in course of erection. The condenser of each unit, which, together with its pumps and auxiliaries, is located in the basement between the turbine foundations, is of the Alberger centrifugal-jet type and connects with its turbine through a short direct-exhaust duct. The circulating and discharge pumps for each condenser are mounted in tandem in each case and are driven by a single Westinghouse compound single-acting engine, and a steam-driven two-stage dry-air vacuum pump is also provided for each unit. The injection water for the condensers is pumped from the intake tunnel originally provided, which extends the length of the power-house basement at one side of the foundations, the discharge from the condensers being through a similar conduit, parallel to and above the intake tunnel. As the water level in the Ohio River during times of flood is occasionally as much as 28 ft. above the tunnels, special provisions were necessary to guard against flooding the condensers. This has been accomplished by means of an adjustable gate in the intake tunnel leading from the screen house to a large central well, in which the water level may be maintained at will at the desired point, irrespective of the flood level.

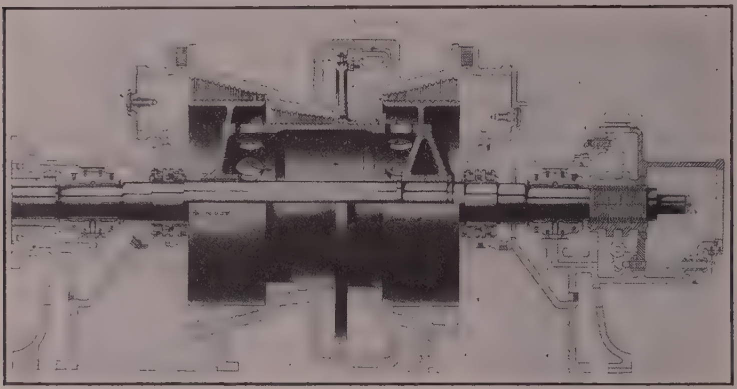
An excellent example of the small foundations required for steam turbines is furnished in the design adopted at Brunot Island; each unit rests upon reinforced concrete plates, supported entirely by six reinforced-concrete columns, thus giving ample space around the condenser, which could have been placed entirely within the turbine foundations had this been necessary. It may be interesting to state here that the concrete employed to construct a foundation for one of the 1,500-kw. cross-compound engine units would be sufficient to build the four foundations required by the 18,000 kw. in double-flow turbines.

The interesting feature of the new installation is the new double-flow turbine. The double-flow principle, as embodied in these large machines, is essentially a modern development brought about entirely by considerations of the requirements of mechanical construction. It is not without precedent, the original Parsons turbine constructed in 1880 having been of the simple double-flow type, and in modern hydraulic practice the double-flow principle is very largely employed to produce a rotary element running in perfect axial equilibrium. The details of the double-flow construction will probably be most clearly understood by first considering the low-pressure design of double-flow turbine shown in an accompanying illustration. This turbine is of the simplest possible construction, consisting entirely of two identical Parsons turbines placed end to end, taking steam at the center and exhausting at both ends. As the two elements are identical and the steam flows through them in opposite directions, the axial thrust of the steam on the blades, due to the difference of pressure between the inlet and outlet of each element, is exactly the same in both sections, so that perfect steam balance under all conditions of pressure, vacuum and load, is obtained without the use of dummy or balance pistons. As this low-pressure design of turbine is intended to utilize all the exhaust steam from a non-condensing reciprocating engine, it is possible to tie the engine and turbine together electrically, thus making the use of a governor on the low-pressure turbine unnecessary. With the exception of the omission of the governor, however, it is practically identical with the high-pressure double-flow turbine. In fact, the high-pressure machine is directly evolved from the low-pressure by the simple addition of a high-pressure impulse element mounted at the center of the rotor, this simple element serving in a capacity closely analogous to the high-pressure cylinder of a triple-expansion reciprocating engine. Another illustration represents this final step in the evolution of the present complete high-pressure machine. This design has become the standard of the Westinghouse Machine Co. for sizes above 3,000 hp., the combination of the impulse and reaction principles having many advantages for the large capacities at high speeds.

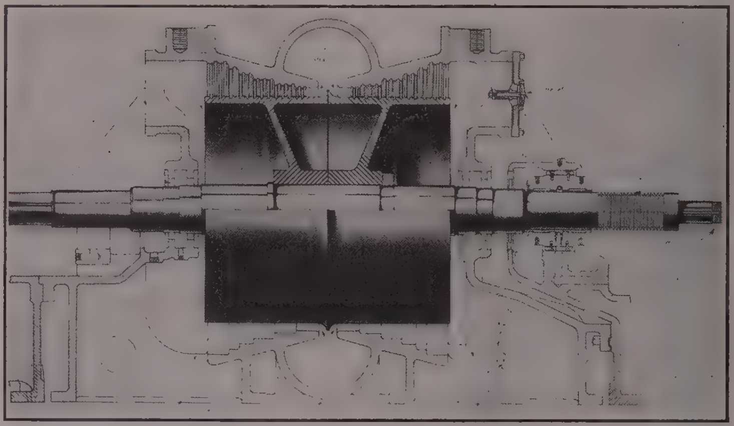
At this point it may be well to point out some of the striking features of the double-flow turbine: First, large reduction in bulk and in weight of individual parts to be handled in assembling, as a result of increased speed permissible, due to reduced span between bearings; low-pressure section in two parts, opposed in position, resulting both in axial equilibrium and permitting the use of low-pressure blading of moderate length. Second, rotor cylinder not exposed to high-pressure and high-temperature steam; maximum pressure encountered about 75 lb. Third, relatively large volume per pound of steam at admission to first Parsons section avoids necessity of the very short blades otherwise necessary with large diameters. Fourth, only one balance piston is required and this of moderate diameter. Fifth, impulse element best adapted to high pressure and superheat; and well suited to the dimensional scheme, reducing shaft length nearly 50 per cent.; and, sixth, exhaust connections, passing through the bed-plate in two sections, largely reduced in size, due to the divided flow.

Steam enters the turbine through a flanged opening in the lower half of the casing, from which it is piped directly to nozzle blocks. For convenience in illustration, one of the nozzle blocks is shown at the top. The steam expands in suitable nozzles and impinges upon the impulse blades, enters the impulse-wheel chamber and is distributed evenly around the casing so as to enter the intermediate Parsons section of the turbine around the entire periphery of the rotor. The steam then, as in the single-flow turbine, divides along two separate paths, one-half entering the left-hand section of the low-pressure Parsons blading and the other half passing through the interior of the rotor shell, which forms the connecting passage to the remaining low-pressure blading; the steam passes next into the exhaust connections and to the condenser.

As the same pressure exists on both sides of the impulse wheel disc, the latter is not subjected to any end thrust and requires no balancing. The difference of pressure between the inlet and outlet of the Parsons intermediate section is accurately balanced by a dummy piston of moderate dimensions located between the impulse wheel and the right-hand low-pressure section. And since the thrusts in the low-pressure sections are in opposite directions and therefore balanced, the entire turbine runs in perfect equilibrium under all conditions of vacuum, pressure and load. For the purpose of accurately fixing the axial position of the rotor an adjustment bearing of the usual construction is fitted on the right-hand end of the shaft; this bearing consists of a number of collars turned in the shaft, into which fit corresponding brass rings fixed in the adjustment blocks. The upper and lower halves of the adjustment bearing may be moved by means of micrometer screws, as shown in the diagrammatic section, thus permitting the axial position of the rotor to be accurately known at all times.



Sectional View of the New High-Pressure Double-Flow Turbine.



Sectional View of the Original Low-Pressure Double-Flow Design.

The cylinders of the double-flow turbines are made in two parts, the upper and lower halves each being a one-piece casting. The design is symmetrical throughout, devoid of longitudinal flanges, except those at the center required for bolting the two parts together. The castings are first rough bored, after the flanges have been planed and drilled, and are then "seasoned" with high-pressure steam for a number of hours to remove any local casting strains in the metal. They are then given the finishing cut assembled, with boring bar running in the bearing housing so as to insure a truly concentric bore. Manholes are provided at each end of the cylinder to permit access for interior examination, and relief valves are fitted in each of the manhole covers to prevent the pressure in the exhaust passages rising to a dangerous point in case of failure of the condensing apparatus and sticking of the atmospheric relief valve. A steam and air-tight packing gland is fitted at each end of the cylinder where the shaft enters, which will later be described in detail. The exhaust connection consists of a Y-fitting that is attached, with corrugated copper expansion joints, to the two exhaust outlets at opposite ends of the cylinder below the base of the turbine, the arrangement of which is clearly shown in the accompanying longitudinal elevation of the 5,000-kw. Brunot Island turbo-generator. By means of these expansion joints the desired freedom of movement of the turbine casing, due to expansion and contraction, is provided for. It is also to be noted that the atmospheric exhaust nozzle permitting non-condensing operation opens out of the side of this exhaust Y-fitting.

The rotor consists of five cast-steel members mounted on a through shaft, the shaft carrying its load at one-third distance from the points of support; this permits a lighter shaft than required for distributed loading and practically eliminates the possibility of deflection. These members are firmly pressed on the shaft and locked at one end to prevent movement, while to the opposite end of the rotor is fitted a bronze bushing surrounding the shaft, permitting it to move axially without appreciable resistance under any differential expansion of shaft and rotor body.

The impulse element consists of a flanged cast-steel disc forced onto the rotor body with a pressed fit and securely keyed. The flange at the base is grooved and forms the dummy or balance piston for the intermediate Parsons section. A typical arrangement of blading and nozzles is shown in detail in one of the illustrations. It will be noted that the nozzle block is an independent casting entirely separate from the turbine cylinder and receiving steam from the governor valve; this restricts high pressure and high temperature to a comparatively small casting, which is free to expand and contract with changes of temperature and may easily be designed with ample strength. As the steam is not expanded in the impulse element to less than about half of the initial pressure, nozzles of divergent bore are unnecessary, and simple straight-sided nozzles are used. The entire nozzle block may be removed in one piece, and the construction is such that the nozzle walls may be readily renewed, if necessary, at a very nominal cost and independently of the block. As practically no difference of pressure exists on the two sides of the element, the area through the buckets increases to provide for the decreasing steam velocity in each rotating wheel. As in all high-pressure impulse turbines, the nozzle blocks cover but a small portion of the periphery of the impulse wheel, so that ample space is left around the remaining portion of the wheel to permit the free circulation of steam in all parts of the impulse wheel chamber before entering the Parsons element.

Except for the division of the low-pressure Parsons section into two parts, this element of the turbine is identical with the single-flow construction, consisting of a series of rows of moving and stationary blades, increasing in height to allow for the increased volume of the steam. In the Parsons section, it will be recalled, the velocities from stage to stage remain practically constant. The blades are mounted in grooves cut in the spindle and cylinder body and are securely held in place by caulking soft spacers or distance pieces inserted in the grooves between the bases of the blades. It is to be noted that the diameters of the low-pressure section are so chosen as to permit the same size blades being used in both intermediate and low-pressure sections, thus simplifying the blading considerably. As there are a number of improvements in the Westinghouse-Parsons blade construction that are now used on both the single-flow and double-flow turbines that have not been previously described, reference to them will be made.

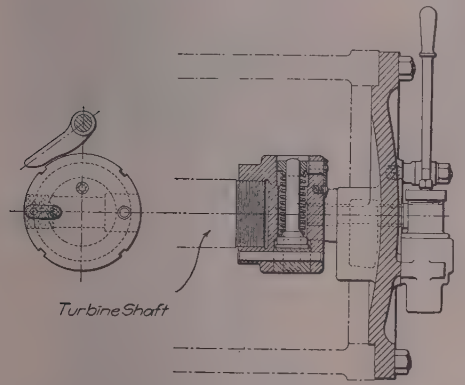
It was early found that no one metal has all the physical characteristics desirable in a blading material, but recently a special compound metal has been developed, which is exclusively used in Westinghouse turbines. This material, known as "Monnot," or duplex metal, consists of a steel core covered with a thin copper sheathing chemically welded to the steel in such perfect manner that the blades may be drawn cold from the original ingot into the required finished section without in any way affecting the bond between the copper and steel. The advantages of this blade material will at once be evident, as experiments have shown that pure copper offers the maximum resistance to chemical corrosion resulting from bad feed water carried over in the steam during priming. At the same time, the integrity and great strength of the steel core is not lost.

The original method adopted for reinforcing long blades, of inserting heavy brass wire in saw slots cut in the entrance edge of the blade, which was securely laced to the blades by a thin copper wire and the whole then rigidly brazed together, has been greatly improved upon in the present blade lashing now used in all Westinghouse turbines, as shown in detail in one of the illustrations. First, comma-shaped holes are punched in the blades at any desired point of reinforcement. The blades are then strung onto a comma-shaped lashing wire through these holes. After the blades have been caulked into the rotor or stator the tail of the comma lashing wire is sheared over by a tool, as shown in the illustration. This process wedges the tail of the lashing wire into the contracting space between the face and back of the adjacent blades, acting as a strut, while the lashing wire itself acts as a tie, thus securely interlocking the blades and preventing vibration. Moreover, the short section remaining in the blade, after being sheared off, acts as a key to prevent a possible broken blade from injuring adjacent rows.

A water-sealed gland is fitted on each end of the turbine shaft, where it passes through the exhaust casings. This packing consists of a small centrifugal pump impeller, running in an enclosed chamber, to which water is supplied under a head of about 10 ft., which is slightly in excess of the head, due to the centrifugal force acting on the water in the impeller blades. At starting, any external leakage water is caught in circular troughs and drained away. The action of this gland is to always maintain a solid mass of water around the periphery of the impeller, which effectually prevents the entrance of air to the condenser or the escape of steam to atmosphere when running non-condensing.

As in all Westinghouse turbines running at or below 1,800 r.p.m., self-aligning babbitt-lined bearings are used, of sufficient area to operate without the use of a forced lubricating system. This bearing is made in two parts, supported in a spherical seat by four pads, by means of which the bearing and rotor can be accurately centered to preserve uniform clearances. The oil supply to the bearings is delivered at the top of the journal at the point of minimum pressure, which assures an even distribution of oil. All the bearings are supplied with oil from a central reservoir, under a simple static head of about 5 ft., to which the oil is returned by a small rotary oil pump driven from the turbine shaft by worm and bevel gearing, after draining from the various bearings and passing through a strainer to remove any impurities and through a tubular cooler. This cooler contains a nest of flat coils, through which cooling water is circulated and is so designed that any single coil can be replaced without discarding the others.

As some form of flexible coupling is always desirable between generator and turbine shaft to provide for any slight changes in the alignment of the respective bearings, an effective form has been developed for the Westinghouse turbines, consisting of two sleeves, one of which is permanently keyed to the generator shaft and the other to the turbine shaft, each having a number of projecting teeth which engage with the projections on a surrounding collar. The latter is made in two parts to permit removing either the turbine or generator shaft without disturbing the other. With liberal end clearance and all surface under pressure practically radial, the coupling allows considerable variations in the shaft alignment and permits the generator shaft to float in its bearings, limited only by a retaining ring at each end.



The Speed-Limit Mechanism.

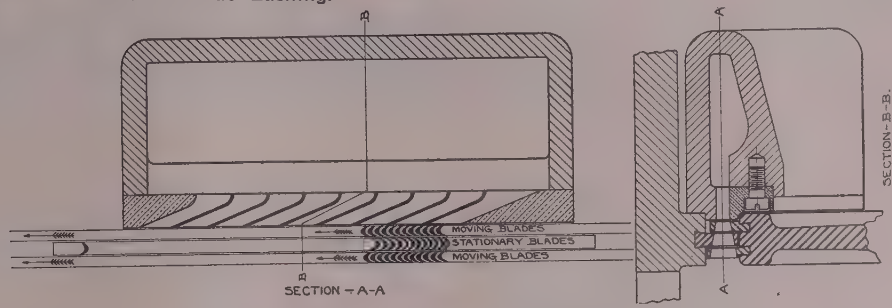
In case of overspeeding the main throttle valve is automatically closed by means of a spring-balanced plunger located at the end of the main shaft, as illustrated in a detail view. Normally the pressure of the spring is so adjusted that the plunger is held to its seat; should the turbine for any reason, however, exceed a predetermined speed the end of the plunger emerges, trips a relay valve and operates a quick-closing throttle. It is to be noted that this throttle valve is closed by releasing the pressure beneath its piston, so that any accident to the pipe connections of the speed limit device would instantly shut down the turbine.

Essentially the same system of governing is used in the double-flow as has become familiar in the single-flow design, namely, the "puff" or "gust" system, comprising a constant number of admissions per minute, with a variable duration of admission according to the load, which is distinctly different from the principle of governing by adding nozzle after nozzle, all at maximum pressure, as the load increases. Both the "puff" method and that of individual nozzle control may properly be regarded as purely mechanical methods of securing a constant-speed prime mover, neither possessing any important thermodynamic significance. In any multi-stage turbine governed by individual nozzle control, however, it is claimed by the Westinghouse Machine Co. to be difficult, if not impossible, to maintain an equal distribution of work between the several stages without a means of governing the nozzles in each individual stage at the same time as the high-pressure stage; on the other hand, theory indicates and experiment proves that with the throttling method of governing, stage pressure control in the multi-stage turbine is entirely unnecessary, and that where the expansion in each stage is but a small part of the total expansion range, as, for example, in the Parsons turbine, the initial and terminal pressures of each stage rise and fall together, resulting in a fairly constant pressure ratio at each successive expansion—in other words, for small ranges and with throttle governing the nozzle and blade areas are reasonably correct through a wide range of load and pressure distribution. For this reason the impulse section of the Westinghouse turbine expanding, say, only one-fifth of the total range, is properly proportioned for a wide range in load and may be governed without resorting to intermediate nozzle control and without any sacrifice of economy at fractional loads.

Details of Blade Lashing.

The type of governor controlling the double-flow turbine is of the sensitive fly-ball type, differing only in minor details from the standard governor for single-flow machines. Its most important feature is that all parts are kept constantly in motion so as to avoid "friction of rest" and prevent sluggish action which would otherwise ensue after running a considerable period at constant load. A small relay steam piston does the actual work of moving the turbine valves, thus relieving the governor of all work, except moving a small pilot valve. For convenience in synchronizing and in the distribution of alternating current load the governor is fitted with a small motor and weight, by which the governor spring tension may be controlled from a distance, usually from the switchboard.

The electrical ends of the turbine units are Westinghouse revolving-field generators of the usual design for direct-connection to turbines. These machines are wound for three-phase alternating current at 11,000 volts and 25 cycles. An interesting feature of their operation at the Brunot Island plant is that they are run in electrical parallel with the two-phase, 6,600-volt generators of the engine-driven units. They are fitted with the usual cooling-air ducts, air being taken in from underfloor connections.



Sections of Nozzle Block, Showing Typical Arrangement of Blading and Nozzles.

The Cost of Circular Concrete Walls.

Some years ago the Fall River Gas Works Co. built a circular brick house around a steel plate oil tank, 36 ft. in diameter and 20½ ft. high. If the tank leaked there would be an outward hydrostatic pressure against the walls of this house, and consequently it was made thick enough to withstand this pressure like a gravity dam. Last year a similar tank was built, but to save cost its house had a reinforced concrete wall. An account of this wall was presented to the New England Association of Gas Engineers by Mr. C. F. Leonard, assistant superintendent of the company, and from his paper the following notes have been taken.

The building is 42 ft. in diameter inside and 25 ft. high above the foundations. The wall is 12 in. thick and reinforced by ⅞-in. round steel rods 2 in. from the outer surface and running horizontally around the wall and also has ½-in. Ransome rods, 18 in. apart and 7 ft. long, bent at right angles and tying the wall and foundation together. The spacing of the horizontal rods ranged from 3½ in. at the bottom of the wall to 30 in. toward the top, and they are lapped 33 in. at the joints; they were attached to vertical rods placed 9 ft. apart so as to keep them in place, but none of the vertical rods were regarded as reinforcement.

The wall was made in movable cylindrical forms, 6 ft. high and 8 ft. long. Their curved surfaces were made of ⅞-in. spruce boards, 6 in. wide, dressed on one side and both edges and nailed to three inside and outside chords. The latter were 2 x 12-in. plank, cut to the proper curvature. The inside surface of the mold was a complete cylinder. For the first three shifts the forms were supported both inside and outside by falsework and braced from the ground outside. A ½-in. wire rope, with two turnbuckles, was stretched around the steel tank, and the forms on the inside were braced away from the tank and drawn to it with telephone wire, passing through the forms near the top and attached to the wire rope. Pieces of wood 12 in. long were placed at frequent intervals to separate the forms from each other, but care was taken to remove them as well as the wire, as the concrete proceeded. To do away with a large amount of outside falsework on the fourth and fifth shifts, which were just above the oil line, the forms were supported by ¾-in. stiff wire rods, threaded, running through near the bottom, fastened by nuts and resting on the concrete. These rods were left in the wall.

The concrete of the bottom 15 ft. of the wall was a 1:2:3½ mixture, using 1-in. broken stone, and less cement was used above that height. It was mixed by hand and wheeled up an incline to a platform level with the top of the forms and between them and the steel tank. It was placed quite wet in 6-in. layers and compacted with flat and wedge-shaped rammers, the latter being used to keep the stone back from the outside face. The bottom ring, 5½ ft. high, was all placed in one day, but after that, in order to keep the carpenters going, the forms were shifted about one-third of the circumference at a time, and the concrete followed along afterward in a spiral fashion. The forms were scraped and greased before each time of use. When it was necessary to stop work at a vertical joint a 2 x 3-in. planed stud was placed so as to make a groove for the bond of the next mass of concrete, and the horizontal joints were broken the same way. The sills and lintels of two doors and eight windows were cast in molds on the ground and afterward placed in position; they were reinforced like a beam fixed at the ends. The wall was painted inside and outside with two coats of neat Portland cement.

The cost of the walls in detail was as follows: Cement at $1.70, $2.81 per cubic yard of concrete; sand at $1.35, 66 cents; crushed stone at $1.20 per ton, $1.42; common labor at $1.75 per day of 9 hours, $4.25; steel reinforcement, $1.65; lumber, nails and miscellaneous supplies, $1.46; carpenters' labor, $5.25; total cost, $17.50 per cubic yard of concrete. The cost of carpenters' labor was fully twice what it should have been, owing to local labor conditions, but, even with this extra expense, the concrete wall cost but 77 per cent. of the brick wall erected in 1902 for a similar tank.

The Telephone System of Train Dispatching has been adopted by the Chicago, St. Paul, Minneapolis, & Omaha Ry. to supplement the telegraphic system, in order to meet new conditions presented by the enactment of the Federal law regulating the hours of telegraph operators who have to do with train orders. Only about every third station is retained as a telegraphic train-order office, communication with the intervening offices being had by telephone. This arrangement has relieved the threatend shortage of operators and has precluded an apparent necessity of closing any of the company's offices.

Sewage Disposal for Private Houses.

By J. B. Neely, St. Louis.

In the smaller cities and villages, works for the purification of sewage are lacking, and in such places the usual methods of disposal are the privy vault and the cesspool. These are so crude that they should give way to something better, and the purpose of these notes is to show the main features of small plants built between 1904 and 1906 from the plans of Prof. A. Marston. In the accompanying sketches, Fig. 1 is a diagram of the usual type of cesspool, constructed of brick laid in mortar, although in many cases they are built of rough stone or curbed with boards.

A plant consisting of a septic chamber, having at one end an upward gravel filter that acts as a strainer for the effluent, is shown in Fig. 2. Plants of this type that have been built are of brick, laid in cement mortar, the cost ranging from $25 to $50, depending on their size and the length of outlet drain.

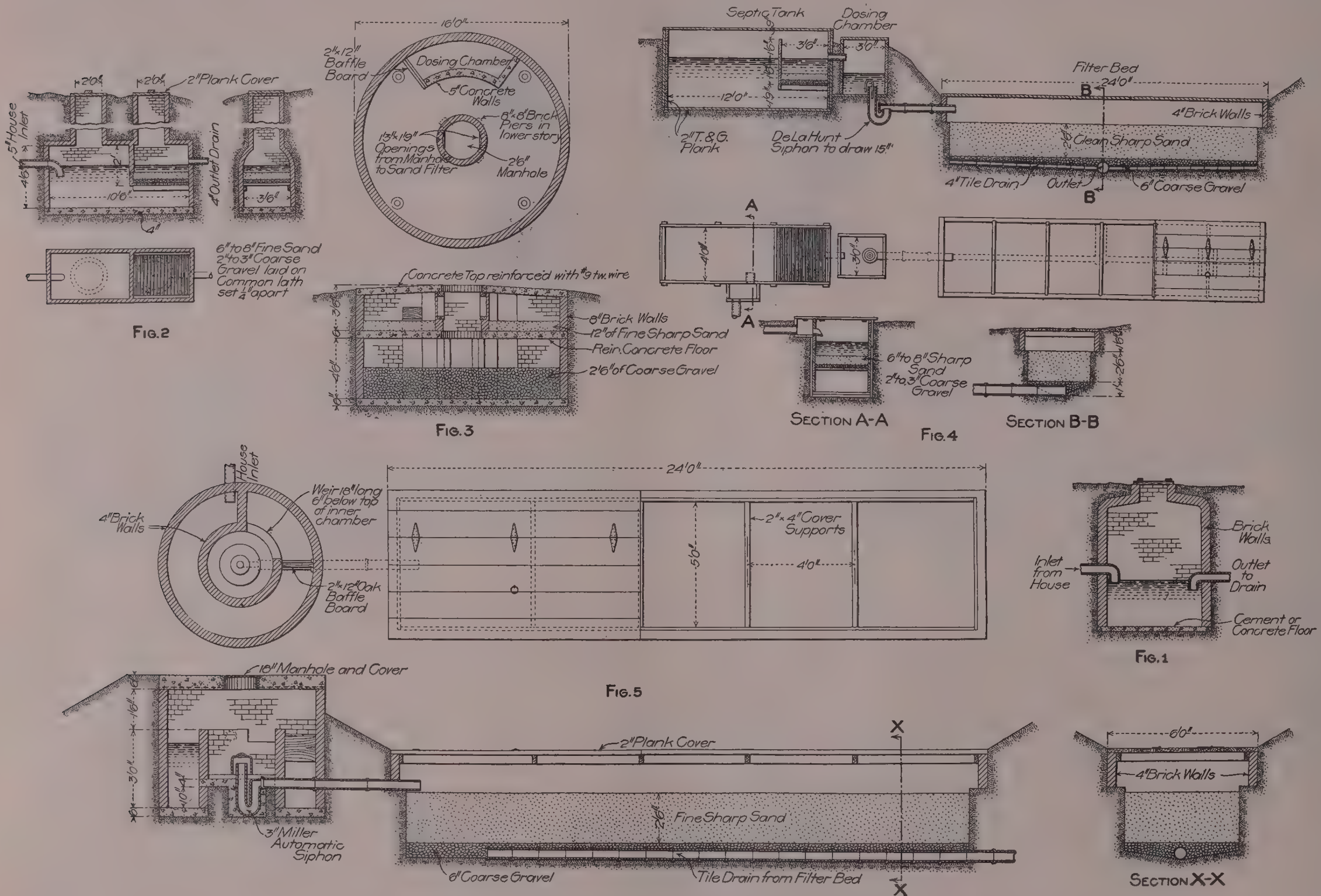


Fig. 2

Fig. 3

Section A-A

Section B-B

Fig. 4

Fig. 1

Fig. 5

Section X-X

Types of Sewage Disposal Plants for Private Houses.

The plant shown in Fig. 3 is circular and combines septic tank, fine and coarse filters, all in one. The sewage runs from the septic tank on to the fine sand filter, which is supported on a reinforced-concrete floor, perforated so that the effluent may trickle through to the coarse gravel filter below, from which the final effluent is carried away by the outlet drain. In this plant fine sand was used for a time in both filters, but coarse gravel was substituted with better results.

The next plant, Fig. 4, was built for the experimental purpose of determining the value of an upward filter in the septic tank, used in connection with a De La Hunt siphon and a complete filter bed.

The most complete type, Fig. 5, has a combined septic tank and dosing chamber built of concrete and brick. The mat is prevented from flowing into the dosing chamber by a wooden baffle board. The doses are supplied to the filter bed by a 3-in. automatic Miller siphon. The baffle board prevents the overflow of any great amount of suspended matter, as the dosing chamber is separate. Agitation when doses are emptied to the beds is very slight. This design is considered more complete than that of any of the others and has given good results.

In all cases the action and results are essentially the same as in larger plants, with one or two exceptions—first, a small plant requires more care to produce good action; second, the filter beds have a greater tendency to clog and require more work to keep them in a good condition. The effluent from the dosing chamber carries a larger amount of finely divided suspended matter than is found in the effluent from a larger plant. This may be explained by the fact that the volume in the dosing chambers is much smaller correspondingly, and this undissolved matter in suspension, not having time to settle, is carried over onto the filter beds.

During the spring of 1907 a series of tests were conducted on all plants described. Samples were taken every three hours for a twenty-four hour period. From the samples complete bacterial and chemical analyses were made, bacterial analysis being quantative only. The plates for the agar-agar cultures were poured immediately after taking samples, so that no changes of the samples might enter into results. In all cases results were very satisfactory, the reduction in bacteria being from 94 per cent. maximum to 41 per cent. minimum, the plant giving high percentage being in a perfect condition, while the one with the low average had been in operation for over two years, with no attention and a filter bed in a very bad condition.

A comparison of the effluent of the plants and samples taken from cesspool drains showed cesspool effluent to be five times as bad bacterially as the worst disposal plant effluent.

One thing that must be noted is care of outlets. Outlets should always be kept free from rubbish and should have sufficient grade to insure perfect drainage, for the outlets of plants examined were found to contain stagnant water and to have an independent septic action.

The upward filter, as used in plants of Figs. 2 and 4, was found to be effective, keeping down the percentage of sediment that is carried to the filter bed. To insure a complete action a filter bed is necessary, the double system of plant, Fig. 3, giving the best results. For the other style of filter beds, Figs. 4 and 5, care must be taken to keep them in condition so that sewage may filter readily and re-aeration take place rapidly. This is done by raking and hoeing tops and spading once in three or four months. The original cost of the plants was: Fig. 2, $25 to $50; Fig. 3, about $100; Fig. 4, wooden, $75; Fig. 5, $80 to $100. The cost of keeping them in condition is scarcely appreciable for the year. The private sewage disposal plant to be a success, first, must embody all the essential features of a larger plant; second, must be properly cared for and must be large enough for complete bacterial action. Sewage disposal plants are not "foolproof," but are in need of constant care and attention.

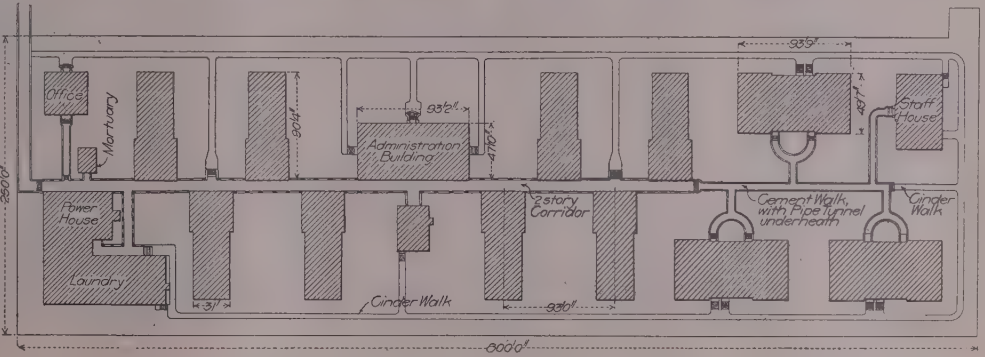
Cribs for Island No. 3 in Place, with One Section Sunk, Ellis Island.

The Water Supply of Copenhagen is derived from 5-in. wells bored through glacial deposits overlying a stratum of chalk to which, or into which, the borings extend. Upon reaching the chalk, if it be found covered with coarse material, the well is not pushed further, but should the covering layer be of fine grain, then the boring is extended into the body of the chalk itself. The supply was the subject of a paper by Dr. Wm. P. Mason, before the recent convention of the American Water Works Association. The wells are from 150 to 200 ft. deep, and are sunk at an expense of about a dollar per foot. The water is very hard and is softened by private plants for industrial uses. The city, however, removes only the iron carbonate, which amounts to 4.1 parts per million. This removal is accomplished by aeration and filtration. The water is delivered to open cast-iron troughs, 24 in number, each 12 ft. long, 8 in. deep and 8 in. broad. The water overflows and falls in thin sheets into the collection well, 8 ft. below, the soluble iron being thereby oxidized to the insoluble form. The water then flows 14 miles to the filter plant in the city. The rate of filtration on the 75 x 150-ft. beds is 8 vertical inches per hour and the depth of the sandbed is 4 ft. The only function of the filters is to remove the suspended iron. The filters are cleaned every nine days, except during the winter, when the time is extended to about 40 days by breaking up the "Schmutzdecke" with rakes without removing the water. It has been proposed to increase the time between cleanings by passing the water rapidly through small "roughing" filters of gravel and small stones before allowing it to flow upon the filters.

Recent Improvements at the United States Immigrant Station, Ellis Island, N. Y.

During the past three years extensive improvements have been under way at Ellis Island, N. Y., the United States Immigrant Station, in the Upper Bay, New York Harbor, consisting of the construction of an entirely new island, with an area of 4¾ acres, and of a group of seventeen buildings, forming a hospital for the treatment of contagious diseases. At the present time twelve buildings of the group are either entirely or almost completed and will shortly be ready for occupancy.

Ellis Island is located about 1¼ miles from the nearest point of the lower end of Manhattan Island and originally consisted of an irregular tract of land, which, after being extended and enclosed by a timber bulkhead, gave the main island an area of 11.03 acres. Subsequently another island, called Island No. 2, was added southwest of the main one. This second island is rectangular in shape, has an area of 3.31 acres and is connected with the main island by a narrow covered passageway. Between the two is a slip, which affords docking facilities for the small vessels which take the immigrants from the incoming ocean liners, and for a slip for the ferry which connects the Immigrant Station with the U. S. Barge Office at the lower end of Manhattan Island.



Plan of Contagious Hospital Group, Ellis Island, New York Harbor.

The buildings now in use, which were completed some years ago and were described in The Engineering Record of July 27 and Aug. 3, 1901, are located on these two islands. The group on the main island contains the Main Building, so called, in which the registration and inspection of the new arrivals take place; a bath and laundry building, a restaurant building and a power house, which heats and lights all of the buildings of the station; Island No. 2 contains the main hospital building. These buildings are uniform in general type of construction, the walls being built of red pressed brick, with stone trimmings.

The new island built for the contagious hospital group is known as Island No. 3 and lies directly southwest of Island No. 2, to which it is connected by a passageway similar to that between the first two islands. It is 250 ft. wide, 800 ft. long and is separated from Island No. 2 by a slip 225 ft. wide. The site now occupied by Island No. 3 was, prior to the inception work in June, 1905, a mud flat, covered with a maximum of about 4 ft. of water at low tide. Operations were started by dredging a trench approximately 32 ft. wide in which to sink the timber crib bulkhead extending around the area to be filled. The trench extended to hardpan at a minimum depth of 15 ft. and a maximum of 26 ft. below low-water level. The crib was built alongside the dock of Island No. 2, hauled to place, anchored to dolphins and sunk to bearing on the hardpan by filling with rock ballast. It was built of yellow pine logs in pockets 8 ft. square, and, the alternate pockets being floored, allowed every second section to be securely anchored by the rock filling working into the hardpan, while the floor section held the ballast for sinking the crib. The latter extends to an elevation 12 ft. above low water, making the maximum depth of crib from the top down about 38 ft.

While the dredging of the trench for the crib was in progress a sufficient area was dredged outside these lines to allow tugs to haul stone scows close to the cribs, in order to fill the latter. When all of the cribs were sunk the site showed a rectangular body of water enclosed on all sides. The next step was to fill this enclosed area with material obtained from the dumping boards located on both the Hudson and East Rivers, in the city of New York. It was composed of rock from building excavations, street sweepings, ashes and some rubbish. The material, however, did not contain any garbage. It was loaded into bottom-dump scows, towed to the island and dumped below water in the trench outside the timber cribs. Dredges with clam-shell and orange-peel buckets picked up the material and dropped it within the crib lines. Nozzles supplied with water by 4 x 6-in. steam pumps on each hose line were located beneath the dumping points of the buckets, when the fill had progressed above water level, in order to wash the fine material to the center of the island. Some sand was dredged from the Lower New York Bay and flushed to place in the center of the filled area. No wheeling was necessary in the construction of the island, except in placing the material for the top dressing.

The construction of this island was completed in July, 1906, at a cost for the 4¾ acres, including all the necessary channel and basin dredging, of $143,000, or at a rate of $30,000 per acre.

The arrangement of the buildings on Island No. 3 shows an interesting solution of the problems arising in the design of a hospital for the treatment of contagious diseases. The seventeen buildings in the group are entirely isolated from each other, and access to all of them, with the exception of the four farthest to the east, is had through a two-story walk running through the center of the length of the island. The buildings are arranged on both sides of this walk and at right angles to it in staggered fashion. Six of the buildings are not devoted strictly to hospital uses, these six including an administration building, a house for the staff, a general office building, a mortuary, a kitchen and a power-house and laundry building.

The remaining buildings of the group, eleven in number, are devoted strictly to hospital purposes, the number being made large not only to enable the separation of different kinds of diseases, but also to separate the men, women and children. The idea of isolation is carried still farther by means of the double walk, which allows access to the second floors of the buildings without exposing the patients above to the contagion of the disease confined to the first floor. Additional provision for the use of each hospital building for two different diseases is further made by entirely separating the stairway connecting the second floor with the lower story of the covered walk from the entrance to the first floor. The interior of the buildings follows the best designs for hospital construction, being sanitary in every respect. Terrazo floors and marble wainscots are used in all toilets and bathrooms, the plumbing is of the exposed type, and rounded corners and unpanelled doors are used throughout.

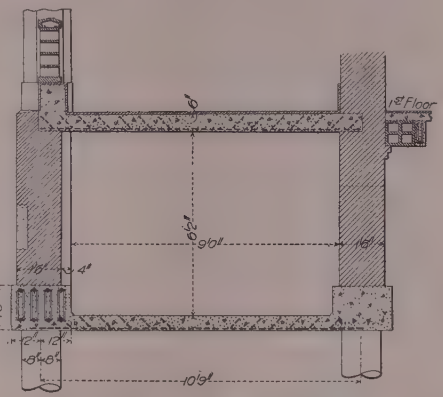
The character of the material used in making the island introduced a foundation problem rendered still more difficult by the complete saturation of the sub-soil, and the danger of foundation pits and trenches filling with water during construction, both from seepage and storm waves. The buildings on the main island are founded on wooden piles, cut off below the ground-water level and carrying heavy concrete foundations above this point. The digging of the pits to make this cut-off was attended with much difficulty from storm and seepage water, as just mentioned, and made the foundations costly. The successful solution of these problems was accomplished in the case of the new hospital group by the use of concrete piles, of which between 1,400 and 1,500 were driven for carrying the seventeen buildings and the two-story walk of the contagious hospital group. Not only was it unnecessary to cut off these piles below ground-water level, but they were, moreover, carried up to the surface of the ground itself, and in the case of hundreds of piles to elevations from 2 to 4 ft. above the surface. The piles beneath the exterior walls were, as a rule, at or immediately below ground level, while those within the interior of the structures were carried up to whatever elevation was required by the floor beams of the first story.

Two-Story Covered Walk Connecting Hospital Buildings.

Contagious Hospital Building, Showing Pebble-Dash Finish.

Raymond concrete piles were used exclusively. The shells or forms were of 20-gauge sheet steel and were driven by a core propelled by a 3,000-lb. Vulcan steam hammer, falling 3 ft. The piles average 32 ft. in length, are figured for a safe carrying capacity of 30 tons each and are driven until the final inch of penetration requires ten blows of the hammer. They measure 16 in. in diameter at the butt and 8 in. at the tip. The maximum length is about 37 ft.

When the work was started it was found that the soft material, of which part of the island was made, collapsed the shells, this being discovered in the inspection to which each casing was subjected before allowing the concrete to be placed. The inspection was easily made by dropping an incandescent lamp down to the very tip end of the casing. The natural thing to do to prevent the shells from collapsing in the soft stratum was to use some type of reinforcement for the shell. This was effected by inserting a collar of 18-gauge steel, from 6 to 8 ft. long, through the dangerous section. This effectively stopped the distortion of the casing, and no further difficulty was experienced in the work. An average of 25 piles were driven per day.



Pipe Tunnel under Covered Walk.

The piles are in all cases capped with concrete beams, reinforced with Kahn trussed bars, and these beams were placed, if necessary, the day after driving the piles. It may be remarked here that the Kahn system of reinforcement is used not only for the beams and girders of the floor system and for those carrying the walls and partitions, but also that the Kahn combined system of reinforced concrete and terra cotta floors is used throughout, thus insuring a thoroughly fire-proof construction. Reinforcement, consisting of four round rods, ¾ in. in diameter, tied together by 1½ x ⅛-in. bands, was used in those piles which projected above the ground surface. This reinforcement ran about 2 ft. 6 in. below ground level and up to the under side of the beams.

The covered walk which has already been referred to a number of times, in addition to its advantages of a sheltered connection between all of the buildings, affords room beneath its first floor for all piping and wiring from the power plant and the administration building, and between the buildings themselves. Heating and lighting is effected entirely from a central power station on the main island, the pipes and wires running from island to island in a suitably covered box alongside the footwalk already mentioned as connecting the three islands. A section through the pipe tunnel beneath the first floor of the walk is shown in the accompanying illustration and, as will be seen, has both the floor and the roof composed of a reinforced concrete slab. Its width is 9 ft. and height 6½ ft.

The power-house, on Island No. 3, already referred to, is to be reserved entirely as a spare, and the machinery for fitting it will be taken from the present power-house on the main island, the installation of an entirely new equipment in the latter now being in progress.

The buildings are finished exteriorly in pebble dash, with red brick quoins, trimming and belt courses. Red Celladon tiles are used for the roofing. Catskill cement was used entirely in the construction.

The total cost of the buildings of the contagious hospital group is $750,000. They were designed under the direction of the Supervising Architect of the Treasury Department and were built under the superintendence of Chief Engineer Alfred Brooks Fry, U. S. Treasury Service, superintendent U. S. Public Buildings, Port of New York; F. S. Howell, civil engineer, U. S. Immigrant Service, being superintendent of construction immediately in charge. The Northeastern Construction Co., of New York City, Mr. D. A. Garber, president, was the contractor for the buildings, and the Raymond Concrete Pile Co., New York, put down the piles. The two islands added to the Immigrant Station since 1898 were designed and constructed under the direction of Chief Engineer Fry and Civil Engineer Howell.

THE WATER SUPPLY for the engines of the El Paso & Southwestern Ry. in southeastern New Mexico is carried along the line a distance of 116 miles from Coyote to Santa Rosa, the latter point being 148 miles from the point where the water is diverted from Bonita Creek, 32 miles from Coyote. The water flows to the railroad by gravity, but must be pumped through an elevation of 925 ft. for delivery along the line. Wyckoff wood stave pipe is used for pressures up to 130 lb. per square inch, and cast-iron pipe for higher pressures, the maximum being about 310 lb. The water tanks along the line are supplied from the main through pipes closed by float valves, set so as to keep the tanks full at all times.

Repairs to a 72-Inch Steel Main under 30 Feet of Water.

Abstract of a paper presented before the American Water Works Association by A. W. Cuddeback.

The pipe to which these repairs were made is a part of the plant of the Jersey City Water Supply Company furnishing Jersey City, N. J., with water. This line, about 21 miles long, extends from a large storage reservoir at Boonton, N. J., across country to Jersey City, and consists of concrete conduits, tunnel and steel pipe. The portion of this line in question under the Hackensack River was laid in 1902, and consists of 11/16 in. riveted steel pipe, 6 ft. in diameter. [A complete description of this river crossing and of the methods followed in constructing it was printed in The Engineering Record of Dec. 13, 1902].

The method employed in laying the pipe was as follows. The pipe was furnished on the ground in about 28 ft. lengths, made up of four sheets. These were connected upon the west bank of the Hackensack River on staging suitable for the purpose, carried out across the river and supported on floats. As the pipe was connected, it was enclosed in reinforced-concrete rings, which were made in forms and slipped over the pipe and afterward grouted, making eventually a continuous concrete covering, the weight of the pipe and concrete covering being just sufficient to sink it. After the pipe composing the river crossing was completed and entirely supported by barges it was lowered to its final position in a trench that had been prepared for it by dredging.

At the time the pipe was lowered into place and just as it was filled with water a break occurred in a field joint at approximately the center of the river. This break was first noticed Dec. 15, 1902, shortly after the pipe was lowered into place and filled with water and before the ends of the pipe were connected to the balance of the line. After discussing the possible character of the break and the method to be employed in repairing it, it was decided to build bulkheads in each end of the pipe, force the water out by air pressure, go in and make an examination. After considerable trouble the contractor who laid the pipe, and who was making the repairs, succeeded in getting the water out on about Jan. 10, 1903. It was then discovered that the pipe had opened up. In other words, a plate had parted about seven-eighths of the way around the pipe, the widest opening, 2½ in., being on the bottom. It was repaired by putting a complete ring of steel plate inside the pipe over the break and fastening this plate with stud bolts. The ring was put on in five pieces and the repairs finally completed about Feb. 16, 1903, two months after the break was first discovered.

No further trouble was experienced with this pipe until some time in 1904, when an examination of the river crossing developed the fact that there was a small leak. This was discovered by the sound, which was plainly audible, when passing over the pipe in the river in a boat. In November, 1904, a diver was employed to make an external examination of the pipe, but he could discover no evidence of a leak, except the noise. Shortly afterward it was observed that considerable water was being lost between Boonton and Jersey City. The measurement of the water flowing into the pipe was made through sluice gates at the intake at Boonton, and at Jersey City through a 72-in. Venturi meter. The noise at the river crossing made by the leak continued to increase, and the difference in the quantities, as measured at Boonton and Jersey City, also increased until the loss was between five and six million gallons daily.

In the fall of 1907 a diver was again employed to examine this pipe from the outside, and when this examination was made, Oct. 7, 1907, it showed that there was a substantial stream of water coming out of the pipe at about 80 ft. from the westerly edge of the river and in nearly 30 ft. of water. The diver reported that the stream coming from the pipe was of sufficient velocity and volume to force his body to one side when he passed in front of it; that there was a hole in the concrete covering on the side of the pipe about 10 in. square, and that the velocity was so great that he could not feel of the pipe to determine the character of the injury to the steel plates. The diver's description of the leak and the quantity of water being lost was evidence enough that repairs should be made at once.

It was at first decided that repairs might be made more economically without the aid of air pressure, and plans were made to get at the leak by pumping out the water. This pipe crossing in the Hackensack River is in the middle of the Hackensack Meadows and about two miles from the nearest point that could be reached by wagon road and at least two miles from the nearest point where power could be obtained. After considering the feasibility of getting electric power to operate the pumps, which would of necessity have to be placed inside the pipe, in order to handle the water, it was decided that the cost of getting electric power would be excessive, and the difficulty of getting a steam plant there and handling the exhaust pipes within the main pipe led to the decision to abandon this method and make the repairs by means of compressed air.

A compressed air plant of sufficient capacity to handle the job, together with the necessary boiler power to operate it, was secured from the O'Rourke Construction Co., of New York, shipped to the river crossing by barge and set up on the west bank of the river. At about 400 ft. west from the break a 48-in. tee had been placed in the line when it was built, with a main line 48-in. valve on either side of it and a 48-in. valve on the tee; also a main line 48-in. valve on the east side of the river. This afforded means of getting into the pipe without cutting the main line. An airlock was obtained and fitted to the flange of the valve in the tee, the plant set up and got in working order. About 200 ft. east of the 48-in. branch, which afforded a means of entering the pipe, and therefore 200 ft. nearer the river and the break, was a manhole. As soon as the pressure was off the main line the cover was removed from this manhole, and another cover which had been previously fitted with a 3-in. tapped opening, through which a 3-in. nipple was screwed, was put on in its place. From this manhole a line of 3-in. screw wrought-iron pipe, which had been previously prepared in suitable lengths, was then connected and carried down the 72-in. pipe toward the break as the water was forced out of the 72-in. pipe through the break by the pressure of the air. This 3-in. pipe acted as a discharge for the water after the break had been stopped up, and no more water could be forced out that way, and proved of sufficient capacity.

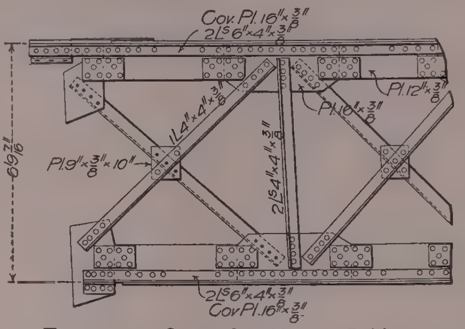
On Dec. 1, 1907, the first move toward getting into the pipe to determine the nature of the break was made. The main line valve on either side of the river was shut down, thus isolating the river crossing, which is about 1,000 ft. in length. These valves were finally closed at about 2 P. M. After these valves were closed the 48-in. valve on the branch was opened and as much water allowed to run out this section of pipe through the airlock as would do so. Then the airlock was closed and the air compressor was started. No difficulty was met in forcing out the water until it got to such a level in the pipe that the air would escape through the top of the break. As soon as this point was reached the air escaped with such rapidity that no further progress could be made toward forcing out the water. Several schemes were tried before it was finally possible to plug up the crack sufficiently to hold the air and force out the rest of the water. It being in the winter time, it was exceedingly unpleasant to wade in water up to one's neck and by hand plug up the crack with clay. Large quantities of waste and gasket yarn were floated out on boards in the pipe and the crack partially plugged in this way, but this method was found to be slow and unsatisfactory. Finally the foreman in charge of the work waded out in the water in a diver's suit and succeeded in plugging up the crack with clay, after which there was no further difficulty in forcing out the water sufficiently to allow men to enter and examine the pipe thoroughly. It was discovered that the pipe had cracked about three-fifths of the way around, the crack being on top and open at its widest part from ⅜ in. to ½ in. This work took all Sunday afternoon, Dec. 1; all day Monday, the 2d, and up to 2:30 P. M. on the 3d, when it was possible to make an examination and determine the nature of the rupture in the pipe. At this time Jersey City was getting short of water and so the water had to be turned

First Floor Beams Placed Directly on Piles, Ellis Island.

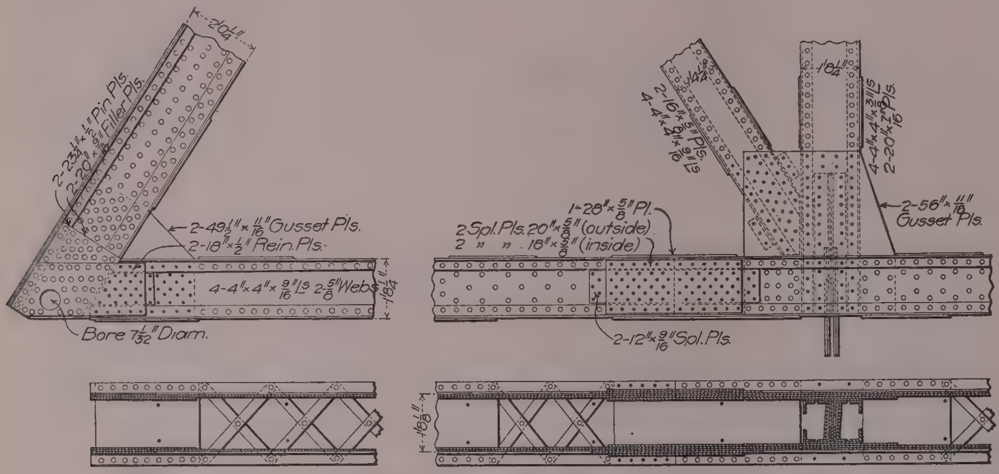
through this 72-in. pipe again, in order to maintain their supply, which was done at 6 P. M., Dec. 3.

Owing to the difficulty of maintaining the supply to Jersey City without this 72-in. main being in service, and therefore the time for making repairs being limited to practically a 48-hour period, it was seen that it would be utterly impracticable to repair this break in the manner that the first break had been fixed. It had been the intention before examining the break to make repairs as before, that is, to rivet on patches with stud bolts, but it was then decided that this could not be done without delay and that repairs must be made in the shortest possible time, and the question was, how repairs could be made so that they might be completed in the least possible time. After considerable discussion of various plans proposed, it was concluded to put an internal ring in the pipe, and the first thought was to make this ring of cast iron. After considering the subject in all its phases, especially the difficulty of handling the heavy weight of iron that would be necessary, it was finally decided to make the internal sleeve of steel plate. This sleeve was made up of three steel plats, 2 ft. wide by 6 ft. long. It was thought that these plates could be bent to form an angle for bolting together, but it was discovered that this could not be done without cracking the plates, so angles were riveted to the plates to form flanges. Set screws were put in the plates to assist in adjusting and holding the sleeve in position in the pipe.

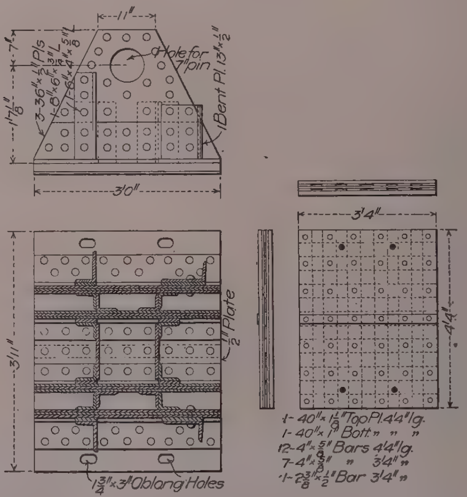
Several materials were considered as filling between the sleeve and the pipe. A patent cement which will expand upon setting was one of the materials considered, but it was rejected as a filling, because of the time necessary for its setting, which in that position would have been at least 24 hours before it would have been safe to let water come in contact with it. Lead in its usual form was rejected, because of the impracticability of pouring the joint completely and the fact that, even if it were possible to pour it, it could not be calked its entire depth. Lead wool was finally decided upon as the material to be used in filling the joint. This was selected, on account of the facility with which it could be handled, the fact that it could be placed in the presence of water and that it could be calked in the entire depth of the joint.



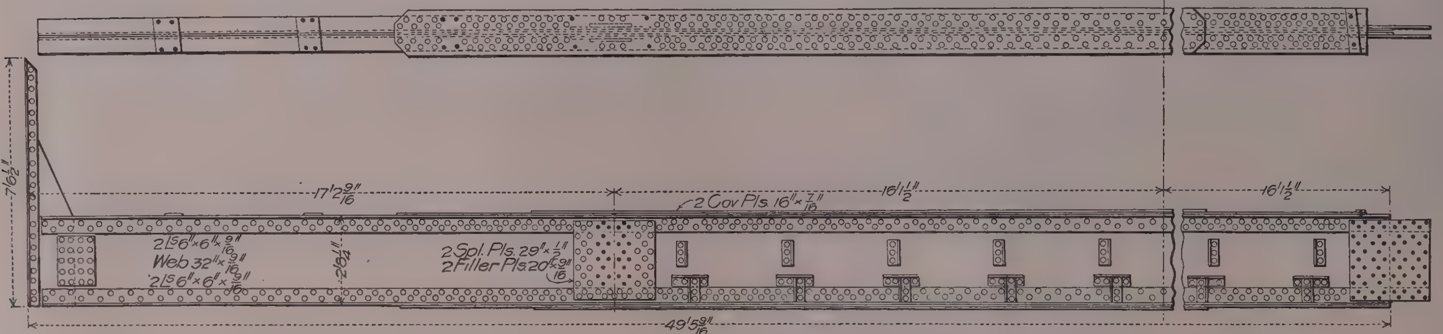
Transverse Strut for Heavy Bridge.



Bottom Chord and Floor Beam Connections and Splice for Heavy Bridge.



Expansion End Shoe and Bed Plate.



Floor Beam for Heavy Bridge on New York, New Haven & Hartford Railroad.

After the first examination of the pipe was made the actual starting of repairs was delayed for several days until arrangement to supply Jersey City with water while the conduit was out of service were made, and the repairs proper were begun on Dec. 19, 1907. The water was turned off at 8:45 A. M. on this date, and the pipe finally emptied below the position of the break, the necessary tools, sleeve, materials, etc., gotten in the pipe by 6 P. M. During the night the sleeve was placed in position ready for the filling material.

After the sleeve was placed in position the center of the joint around the row of circumferential rivets of the pipe and where the crack was located was thoroughly calked with ordinary gasket yarn smeared with clay, in order to prevent the water working in and getting around the layers of lead wool which were to follow and to act as backing for the first layer of lead. Then the filling was continued from either side with lead wool and thoroughly calked to within about 2 in. of the outside edge of the sleeve. This outside space was filled with strips of solid lead, 3 or 4 ft. long, which had been poured in molds the thickness of the joint and thoroughly calked. The work of calking in the lead wool was begun at 6 A. M., Dec. 20, and carried on continuously until finished, and the water again turned on about 7 P. M. of the same day, making the total time that the conduit was out of service approximately 36 hours. The pipe was tested for leakage when the water was turned on and found to be tight.

Special homemade calking tools were used in placing the lead wool in the joint. The men who actually made the repairs worked in two shifts of five men and foreman for each; two hours in and two hours out of the conduit, the same men working in this way from start to finish of the job. The men were all from the regular working force of the company and were selected for their known qualities of endurance, and to their faithfulness is due very largely the successful completion of the job in so short a time.

To Chris McGarry, the general foreman in charge of the work, great credit is due for the careful and complete manner in which he carried out the plans and provided for all emergencies likely to arise in such an undertaking.

Acknowledgment was made by Mr. Cuddeback of the assistance and advice given in planning and carrying out this work to John H. Cook, hydraulic engineer of the company; Edlow Harrison, chief engineer of the company; J. Waldo Smith, consulting engineer, and Fred Gubelman, of the O'Rourke Construction Co., of New York City.

THE CANADIAN RAILWAYS had a total length of 22,452 miles on June 30, 1907, or 27,611 miles including double tracks, sidings and spurs. The greatest mileage in any province was 7,637 miles in Ontario, and the least was 96 miles in Yukon. The dominion and provincial governments have given these roads $181,298,412, besides 31,762,945 acres of dominion lands and 20,420,109 acres of provincial lands. The International road, 485 miles long, was built and is operated by the government.

Erection of Heavy Bridges for the New York, New Haven & Hartford Railroad.

Recent contracts of the Fort Pitt Bridge Works for overhead highway spans on the New York & New Haven R. R. aggregate about 3,500 tons, and as their erection had to be carried on and heavy members handled without obstructing the traffic on the tracks below, a special type of steel traveler was constructed which was adjustable for the different dimensions of these spans and served for general use on other similar erection of the bridge company after this contract was completed. The traveler is of the ordinary two-bent outside-gantry type and weighs about 10 tons. The extreme dimensions are about 30 ft. in height, 16 ft. in length and a width variable from 30 to 40 ft., according to the requirements of the bridges.

Heavy Truss Bridge on the New York, New Haven & Hartford Railroad.

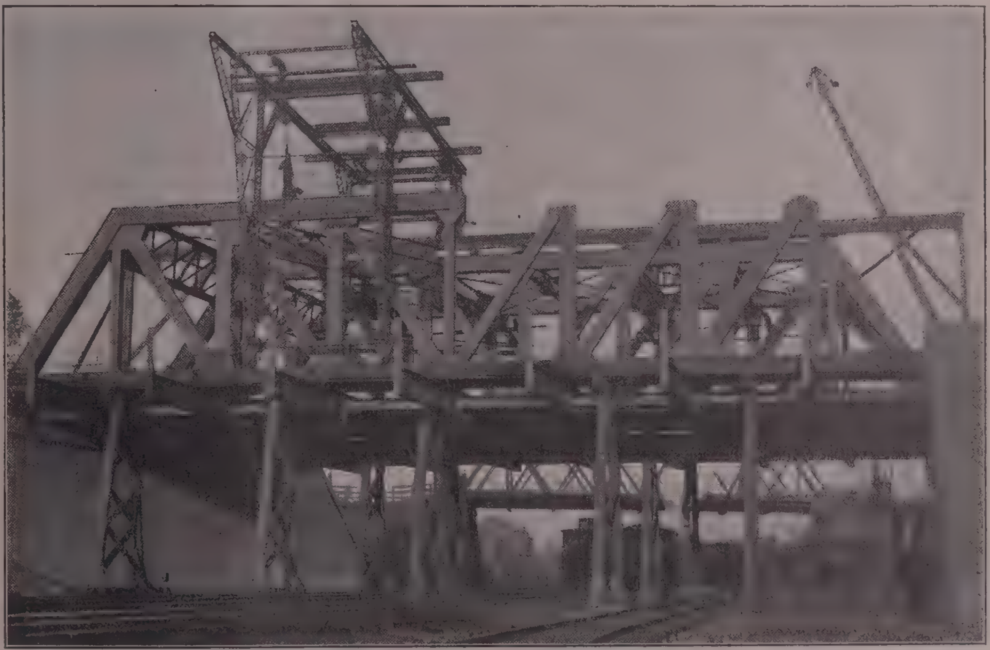
It has four vertical posts, each composed of a pair of 8-in. channels latticed and connected at the top by horizontal transverse struts composed of pairs of 12-in. latticed channels, secured to the columns by four outside and inside knee-braces, each of which has an I-shaped cross-section made with two pairs of angles latticed. The bents are connected by four longitudinal struts in the plane of each pair of columns and by one center longitudinal strut and two other longitudinal struts at the extremities of the transverse struts. All of the panels in the face of the tower are X-braced with screw-end rods, having nuts bearing on double washers. Jaw plates at the foot of each post receive the axle of a single double-flange 15-in. wheel.

All of the vertical posts are made with short pieces connected with jaw plates field-bolted at the splices. The upper sections of these posts are uniformly about 12 ft. long, and by the addition of lower sections of varying length the height of the traveler may be changed to suit the heights of different bridges. The transverse struts are made in three sections each, the center section reaching from column to column and corresponding with the width of the three spans of the first bridge. The ends of the struts projecting outside the columns are made with lighter cross-sections, composed of two 6-in. channels latticed top and bottom and are of uniform fixed length. In case of material variations in the widths of the bridges the original center sections of the transverse struts will be replaced by new struts having lengths made to correspond with the requirements.

By this arrangement it is seen that either the height or the width of the traveler can be varied readily to meet the dimensions of different bridges and thus enable it to serve as a standard tool for general erection purposes. Longitudinal timbers are laid across the transverse struts near the tops of the vertical posts and serve as jigger beams, from which the tackles are suspended in pairs at both ends of the traveler, and with which the top chords and other heavy members are put in position as required.

In the erection of a three-truss bridge the traveler is used like an ordinary traveler for the erection of the center truss and either of the side trusses. The bridges in this group are so detailed that the bottom chords were first assembled on the falsework, then the end posts, the floor system and the vertical and diagonal members of the trusses successively, and finally the top chords were set in place on them and the trusses completed.

After the completion of the top lateral system between the first two trusses the outside ends of the transverse struts of the traveler are jacked up, and the vertical posts are removed and replaced by shorter sections, with their wheels engaged at the lower ends. Transverse timbers or stringer I-beams are then put across the two trusses already erected in the planes of the traveler bents, and, as the corresponding track is laid on the falsework adjacent to the feet of the other full-length vertical posts of the traveler, the traveler is readily pulled transversely across one-half the width of the bridge into the position required for the erection of the third truss, which is then assembled by the traveler, with the long columns of each bent traveling on the falsework and the short columns traveling on the top chords of the center truss.



Bridge under Construction, Showing Traveler and Method of Erection.

As the depths of the trusses vary in different spans, it might be difficult to arrange the short lengths of the traveler columns to correspond; a minimum length was therefore adopted, and the exact height of the track is secured by blocking up stringers or I-beams from the top chords to the required height for the different trusses. Extensions of the track stringers are easily carried from the hip joints to vertical supports over the abutment to enable the traveler to reach the full length of the span.

The traveler is equipped with a single six-spool Mundy hoisting engine, located on the ground near the foot of the abutment. Materials were delivered by cars on the tracks at low grade and were unloaded by a stiff-leg steel derrick, with a 10-ton, 65-ft. boom mounted at the top of the abutment at one end of the bridge. The materials were stored as convenient, either at the foot or the top of the abutment and, as the bridge was erected, were delivered by derricks to a truck on a service track, which carried them to the traveler, or when the traveler was near enough the derrick delivered directly to it. An exception to this method was required for the first panel of bottom chord, members of which were set in place directly by the derrick boom, after which the floor system was assembled and the service track was laid for delivering to the traveler, as already stated.

In these bridges the falsework consists of simple transverse bents without longitudinal bracing and was set by a pair of booms attached to the feet of the front posts of the traveler. As the train service was very fast and trains passed every few minutes, it was impossible to use temporary longitudinal bracing. The bents were therefore kept in position by means of the longitudinal traveler stringers, which secured them until firmly held by the weight of the bridge material. The small bents at the panel points of each truss were made with pairs of 10 x 12-in. timbers latticed on both sides and resting on a mud sill. All field rivets were driven by half a dozen Chicago Pneumatic Tool Co.'s Boyer hammers operated by a Hall Steam Pump Co.'s compressor.

One of the group of bridges erected by this traveler is known as No. 4.75, west of Van Nest, over the Harlem River Branch of the New York, New Haven & Hartford R. R. It makes a skew of 4 deg. 33 min. and 48 sec. with its abutment, is 103 ft. 3 in. long, center to center of bearing, and has three trusses, 20 ft. deep and 32 ft. 2 in. apart on centers. There are two roadways, 22 ft. 10 in. wide in the clear, and the plate-girder floor beams cantilever about 17 ft. beyond each of the outside trusses to carry two sidewalks. The trusses are of a heavy pattern, corresponding to the standard construction of the railroad, have riveted connections throughout and are provided at the ends of the lower chords with pin bearing in riveted pedestals. All main connections are field riveted to pairs of heavy jaw plates, shop riveted to the webs of the top and bottom chords.

The top chords are braced at panel points with skewed transverse struts about 4 ft. deep and with I-shape cross-sections made with pairs of angles back to back, latticed and connected by X-bracing and vertical angles, substantially forming small lattice girders. The portals in the planes of the inclined end posts are of similar construction, about 7 ft. deep over all, and have the flanges reinforced by horizontal cover plates, 16 in. wide, and by vertical web plates, 12 in. wide, in single panel sections, spliced at both ends to the web connection plates which receive the web members.

The pedestals are of ordinary construction, with four webs in each, thoroughly braced together with transverse diaphragms and by rivets through the adjacent outstanding flanges of vertical stiffening angles. At the expansion ends the verticals are seated on nests of segmental rollers, 8 in. in diameter, with the sides planed off to vertical planes, 4 1/16 in. apart, and the ends tap-bolted to longitudinal guide strips, with a horizontal clearance of ½ in. between them, which limits the angular displacement of the segments. The roller beds, 4 in. thick, are made with thick-planed top and bottom plates, separated by three cross tiers of thin filler strips, countersunk-riveted in place. The fixed-end pedestals correspond exactly with the roller-end pedestals, except that they have no center guide strips to engage the groove in the segmental rollers, and the difference in height, due to the omission of the rollers and bed plates at the fixed ends, is compensated for by elevation of the masonry.

The most special feature of construction in the bridge is found in the connections of the floor beams to the trusses by a construction which secures rigidity by means of a simple arrangement of hanger plates adjusted to the skew of the bridge so as to avoid bent connections. Vertical transverse diaphragms, nearly 5 ft. long, are riveted between the main connection plate at the lower-chord panel points, and beveled filler plates are shop riveted to both sides of them, providing opposite parallel surfaces corresponding with the skew of the bridge. The fillers also serve as hangers and project about 30 in. below the lower chord, forming jaws which engage both sides of the floor-beam webs and are field riveted to them.

The floor beams, about 100 ft. long over all, are made in two equal sections, spliced at the center points by the field-riveted web cover plate and the beveled hanger plate which connect them to the center truss. They have a 32 x 9/16-in. single-piece web plate and pairs of 6 x 6 x 9/16-in. flange angles, reinforced with two part-length 16 x 7/16-in. cover plates top and bottom. The flanges have pairs of 15 x 1-in. slotted holes to receive the hanger plate, and the web has reinforced horizontal shelf angles and vertical connection angles riveted to it for the roadway stringers, while the sidewalk stringers are seated directly across the top flanges. The short end sections of the web project over 2 ft. above the top flanges of the floor beams to form gusset plates, knee-bracing pairs of vertical web-stiffener angles, 7½ ft. long, to which are field riveted the fascia girders, 3 ft. 9¼ in. deep; and above them the solid web of a hand-rail girder about 2 ft. deep. The total weight of the span was about 90,000,000 lb., and the heaviest member weighed 9 tons.

The bridge was designed by Mr. H. C. Keith, consulting engineer, to meet the requirements of Mr. Nelson P. Lewis, chief engineer of the Board of Estimate and Apportionment of the City of New York, the design and construction being carried on under the direction of Mr. W. H. Moore, engineer of bridges of the New York, New Haven & Hartford R. R. Co., Mr. W. B. Leonard, engineer of construction, and Mr. I. D. Waterman, assistant engineer of construction, representing the company in its erection.

The Brooklyn High-Pressure Water System for Fire Protection.

During the past few months the city of New York has completed two independent high-pressure fire-protection systems, one in the Borough of Manhattan and one in the Borough of Brooklyn, which are similar in the main ideas, and differ only in the development of details. The Manhattan system was fully described in The Engineering Record of Jan. 4, of this year, while some of the details were described on Dec. 15, 1906.

The following description applies to the Brooklyn system, which covers and reaches beyond the downtown business section of the city and the warehouse district, extending along the East River from the Erie Basin to the Navy Yard, and inland as far as Flatbush avenue, an area of 1,360 acres, three miles long and varying in width from a few hundred feet to one mile. There are in all about 22 miles of extra heavy cast-iron mains from 8 to 20 in. in diameter, which supply about 680 hydrants, each provided with four nozzles. With the eight pumps of the two stations at work 48 streams may be concentrated at any part of the system with a pressure of 200 to 300 lb. to the square inch, each stream delivering theoretically 500 gal. of water per minute. Space is provided for six more pumps in the stations, so that 84 streams can be concentrated at any part of the system.

In addition to the service of the pumping stations, twenty-four connections are provided, so that the pumps of the fireboats can be used to augment the stationary installation. Since the new system is not intended to supplant the use of fire engines, but is to work in conjunction with them, no changes have been made in the present arrangement of low-pressure fire hydrants.

The main pumping station is located at Joralemon and Furman streets, a few hundred feet from the East River, and can be supplied with water either from the city's domestic supply system or from special mains to the East River. By the use of suitable vacuum pumps, automatically operated, salt water, or East River water, is held in the salt-water mains at all times, it being only necessary to open the gates between the salt-water mains and the pump mains within the station, to deliver salt water to the pumps.

The reserve station is at St. Edwards and Willoughby streets and takes water only from the domestic supply mains, as it is located some distance from the water front. Two separate suction mains are provided, each with a sufficient capacity for the entire station.

Both stations are electrically operated by current from the Edison Company, and every precaution has been taken by the installation of duplicate feeders to make the system reliable. Cross connections between the Edison stations, the Brooklyn Rapid Transit and the New York Edison systems allow electrical energy to be drawn from any of the large generating stations in Brooklyn or from any of the stations of the New York Edison Co. in Manhattan.

The pumps and motors have the same capacities and work under the same conditions as those in the Manhattan system, described in the previous article in The Engineering Record. Each pump has a capacity of 3,000 gal. per minute against a pressure of 300 lb. per square inch, operating at 750 r.p.m., with a 20-ft. suction. They are of the six-stage turbine type, direct connected to the motors. The latter are of the induction type, 800 hp, using 25 cycle, 3-phase current at 6,600 volts.

The pumps deliver through 10-in. pipes into either of two 16-in. discharge mains, which are also connected to form a loop within the station. The pumps operate against a pressure of 300 lb., this pressure being reduced, as required, by a regulating valve. As the fire hydrants are likely to be shut off at any time without notice to the station, there is provided between the discharge pipes and suction pipes of each pump a relief valve which can be set to relieve at any pressure from 100 to 300 lb.

All pipes, fittings and valves were submitted to a hydrostatic pressure test of 600 lb. per square inch at the shops, and after being laid were tested to 450 lb. per square inch. The pipe, specials and fittings have already been described in these pages.

For the purposes of operation the system is divided into two districts by an imaginary line, these districts being called the main and the reserve. On receipt of an alarm, for example, in the Reserve district, the operator at the Reserve station, at St. Edwards and Willoughby streets, will immediately start up one pump and put the pressure requested by the fire department on the whole system. This pressure will be maintained by the running of additional pumps if necessary, unless the operator is notified by the fire department. Should the operator at the main station notice by means of pressure gauges that the Reserve station did not start when requested to do so, he is then to put pressure on the mains. The nozzle pressures of the fire streams can be varied by the firemen, either by throttling at the hydrant or by notifying the station operator.

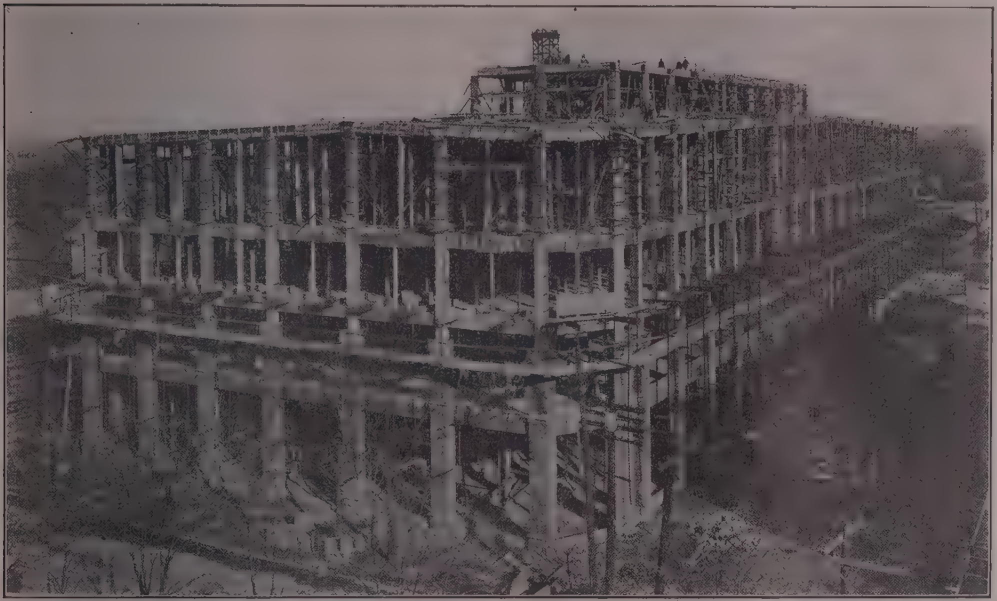
The New York and New Jersey Telephone Co., the Brooklyn public 'phone company, has arranged to supply private telephone service in connection with the operation of the high-pressure fire service system, consisting of a private tie line between the telephone switchboards in the two pumping stations, and one central office line from each of the switchboards; a private line from each pumping station to the switchboard of the Edison Electric Illuminating Co., a private line from each pumping station to the switchboard at fire headquarters and lines from telephone call boxes located near the fire alarm signal boxes (about 112 in all at present) to the switchboards in the stations. Not more than six call boxes are permitted on the same circuit.

The system was built by the Department of Water Supply, Gas and Electricity, Borough of Brooklyn, being started under Mr. I. M. De Varona and finished under Mr. John W. McKay. The contractor for the street mains was Mr. John J. Cashman, of Brooklyn, and for the electrical and hydraulic equipment of both stations the D'Olier Engineering Co., of Philadelphia and New York.

A New Dike to protect the double-track trestle of the "North Incline" of the Southern Ry., over which cars are run onto the car ferry on the Illinois side of the Mississippi River near St. Louis, has recently been completed. Floods had cut into the principal dike protecting the trestle from high water and had finally attacked the trestle itself. In making repairs, a new dike was added at right angles to the channel. An excavation was made about 5 ft. deep and 50 ft. wide; willow mattresses, closely woven and wired, were laid in the trench and covered with limestone riprap, which amounted, according to the "Railroad Gazette," to 1½ cu. yd. for each 100 sq. ft. of mattress. The upstream side of the mattress was dipped about 2 ft. and heavily riprapped at the toe to prevent under-scour. Piling was then driven through the mattress about 20 ft. from the upstream edge.

The Studebaker Office Building, South Bend, Ind.

A reinforced concrete skeleton office and warehouse building of large size has recently been completed in South Bend, Ind., for the Studebaker Bros. Mfg. Co. It measures 321 ft. 6 in. by an average of 110 ft. in plan, has four stories and a basement, and is surmounted by a monitor of exceptional size rising about 13 ft. above the main roof. Besides the size of the building and the large quantities of concrete and reinforcing steel used, the rapidity of construction and the type of reinforcement are of special interest. The structure has a skeleton frame of reinforced concrete and floor slabs of the same material, but the outside walls are of terra cotta and brick carried on the reinforced concrete monolithic skeleton. The contract for the building was signed on July 24, 1907, the first of the reinforcing steel was shipped from the factory of The General Fireproofing Co., at Youngstown, O., on Aug. 10, and the skeleton was finally completed on Nov. 25, 1907. The actual working time can be better judged by dating from the time the basement was completed, Sept. 11, 1907. Between this date and Nov. 25, 413 tons of reinforcing steel and 3,800 cu. yd. of concrete were put in place. The first floor was completed on Sept. 20; the second floor, Oct. 4; the third floor, Oct. 18; the fourth floor, Nov. 11; the roof Nov. 21 and the monitor Nov. 25.



Studebaker Building under Construction, Showing Suspended Scaffold.

The spacing of the columns in a direction parallel with the length of the building is uniformly 16 ft. 6 in., while across the width of the building the spacing is either 16 or 18 ft., with the exception of a 27-ft. bay along one side of the building, and a few cases due to elevator and stairway shafts and the irregular width of the structure. As a rule, all of the floor beams carry their load directly to the columns, the most noticeable variation from this rule being in the 27-ft. bay, above referred to, where beams 18 ft. from one line of columns and 9 ft. from another, transfer their loads to girders of 22 ft. clear span.

All of the floors are designed for total loads of 150 lb. per square foot and the roof for a total load of 125 lb. per square foot. The floors slabs are 5½ in. thick, reinforced in both directions by ½-in. cold-twisted lug bars placed on 9-in. centers, except at those points where an irregular type of framing results in shorter spans, requiring in consequence less reinforcement. These bars as a rule extend continuously through two panels, some of them, therefore, being 38 ft. long, for two 18-ft. panels, the extra foot on each end being for lap.

The floor slabs are designed to carry the proper loading when the bottom of the reinforcing bars is 1 in. above the bottom of the slab. In order to insure this condition to realize the stresses which the steel is intended to carry and to obtain the proper protection from below for fireproofing, the bars are located by small seats or stools having prongs protruding upwards, between which the reinforcing bars are placed. These prongs are then bent down around the bars to hold them securely.

The floor beams, with but a few exceptions in the case of long spans, are 7 in. wide, and 18 in. deep to the top of the floor slab, this size being used where the span between centers of columns is as great as 18 ft. For a few longer spans the width of the beams is not varied, but the depth is made 28 in. The girders, on the other hand, have a width of 10 in., and a depth of 28 in., this dimension also including the thickness of the floor slab.

The reinforcement of beams, girders and lintels consists of "pin-connected" girder frames fabricated by The General Fireproofing Co., Youngstown, O., put together at the factory and shipped flat ready to place in the work. In order to insure a positive bond across the columns, continuous action and resistance to the negative moment over the supports, the frames in adjacent columns were joined together by heavy links and pins, and heavy return bars run out from the column into each beam near the top of the slab, and parallel to the latter. These return bars are part of the main tension steel which run up diagonally toward the top of the beam, starting at about the third points, and are bent back around the pins just referred to. The shear members were rigidly fastened to the main tension members and their position easily fixed at the proper point by suitable clips. In order to insure the accurate location of the center of action of the main tension steel, inverted clips are securely fastened to the frames to hold them the proper distance from the bottom of the forms. These inverted clips, as well as those which hold the shear members to the main tension steel, consist of a collar and wedge device. The wedges are driven by pneumatic hammers and after being driven, cannot be removed by ordinary methods, thus permitting the handling of the frames in transit from the factory to the work without danger of disturbing the proper position of the various bars.

The columns vary in size from 22 to 14 in. square for the interior columns and from 19 x 25-in. to 12 x 16-in. in the walls. They are reinforced in all cases with four cold-twisted lug bars, wired together by ¼-in. lug bar ties, spaced on centers varying from 10 to 18 in., according to conditions. The tie bars are prevented from being displaced by the lugs on the vertical reinforcement. The column reinforcement was also shop-fabricated, so that no work was necessary on the steel at the construction site.

An interesting feature of the structure is the reinforced concrete monitor skylight, 36 ft. wide and 180 ft. long. The columns supporting the roof of the monitor are spaced lengthwise 16 ft. 6 in. on centers, the same as the column spacing in the building itself. In the other direction, however, the columns are omitted across the width of the monitor so that the girders carrying the roof have a span between centers of columns of 36 ft. Floor beams 9 ft. on centers, carry their loads to these girders from each side. The beams are 7 in. wide and 18 in. deep and the girders 14 in. wide and 31 in. deep. Both the beams and the girders are reinforced with "pin-connected" girder frames.

The general contractor installed a 1-yd. Smith concrete mixer in the basement, about midway on one side of the building, and delivered the concrete materials to a platform around this mixer at the first floor level. The materials were wheeled from the platform to the charging hopper of the mixer. The latter discharged into a small hopper in a pit excavated below the level of the basement floor. An elevator tower equipped with an automatically-dumped skip was erected so the concrete could be discharged from the receiving hopper directly into this skip. The guides for the skip in the tower were arranged to permit the skip to be dumped automatically at any floor level on which operations were in progress into a small storage hopper on that floor. From these hoppers the concrete was hauled to place in the forms in wheelbarrows.

The forms for the frame of the structure involve no special features. The column forms in the first two stories were of practically the same size, so that it was possible to use these forms twice. In the remainder of the building the forms for the columns in the lower floors were cut down to the smaller sizes of the upper floor columns. The floor beams and girders throughout the building were of various lengths and sizes, with the result that it was impracticable to re-use the forms for the lower floors, without entirely re-building them. The brick work on the outside of the building was laid from scaffolding suspended from the completed structure. Two 10 x 10-in. timbers were fastened together in a pair with a spacer between them, and a number of these pairs of timbers were cantilevered out from the second floor as struts to carry the scaffold. Two bars of strap iron were suspended from each pair of timbers, and these straps were punched with numerous holes so a horizontal timber to carry the runway of the scaffolding could be suspended from each pair at any height. The scaffolding was carried up as the brickwork advanced, by changing the position of the bolts holding the timbers supporting it, until the second floor level was reached, when the supporting struts were moved to the roof of the building and the brickwork completed with them in that position.

The building was erected for the Studebaker Bros. Mfg. Co., South Bend, Ind. The General Fireproofing Co., Youngstown, Ohio, acted as engineers for the steel work, fabricated the reinforcement, and erected same in the forms ready for concrete. Wells Bros. Co. of Chicago, were the general contractors and Mr. S. S. Beman, also of Chicago, was the architect.

A Concrete Tank at the San Antonio gas works has been in service for three years, holding heavy Texas oil without showing any leakage whatever, although there is a general belief that oil destroys the cohesion of concrete.

Outfall Sewer Extensions in Oakland, California.

The combined storm-water and domestic sewage flow tributary to the sewerage system of Oakland, Cal., is discharged into San Francisco Bay through several main outfalls, which were terminated at the original shore line of the bay when they were built. The bottom of the bay is on a very flat slope for upward of half a mile from the shore, at which distance it is in most places covered with only 6 to 10 ft. of water at high tide. Since the maximum tidal variation is about 6 ft., a large part of this area is therefore exposed during low tide, and as the bottom of this portion of the bay is being raised continually by the deposit of silt brought down by the Sacramento River, the amount of it exposed is increased annually. The general government has established a bulkhead line generally parallel with the shore and 1,770 to 2,000 ft. out from the latter, in order that any projects to reclaim the tide flats thus formed will have this bulkhead as an outer limit. One private company has already purchased a strip of land, nearly a mile in length, between the shore and the bulkhead and contemplates the reclamation of this entire strip. Other similar projects have also been forwarded, so that the shore line will eventually be carried out to the bulkhead.

On account of these changes, two of the main outfall sewers on the western bay shore had to be extended from their original points of discharge at the present edge of the water at high tide to the newly established off-shore bulkhead line. The existing conditions require special design of the extensions and involve much difficulty in the construction work. The original bottom of the bay was fine sand to a great depth, but this sand is now covered with a thick deposit of soft, black mud that is almost fluid. The site of the extensions also being submerged to a depth of 2 to 8 ft. at high tide, necessitates the prosecution of the work to be handled almost entirely during low water.

The extensions are all being built of reinforced concrete on a continuous timber floor carried by stringers on pile bents. The details of the design of the Thirty-sixth St. extension are shown in an accompanying illustration and are quite similar to those of the other extensions which have been made or that are contemplated. This sewer is on a 0.06 per cent. grade, its invert varying from 2 ft. below the present bottom at the shore to a few inches above the bottom at the bulkhead line, which is about the same location as regards the bottom that has been chosen for the other extensions. A horseshoe-shaped cross-section has been used in all the extensions, the width and height of the one shown being 6 ft. The concrete in the sewer barrel is made in the proportions of 1 part Portland cement, 2½ parts sand and 5 parts broken stone. In its entire length the sewer is reinforced with a continuous strip of welded, woven-wire fabric. At the off-shore end longitudinal bars were also placed in the concrete, as shown in the drawing, to provide for any shocks or settlement which may occur at that end.

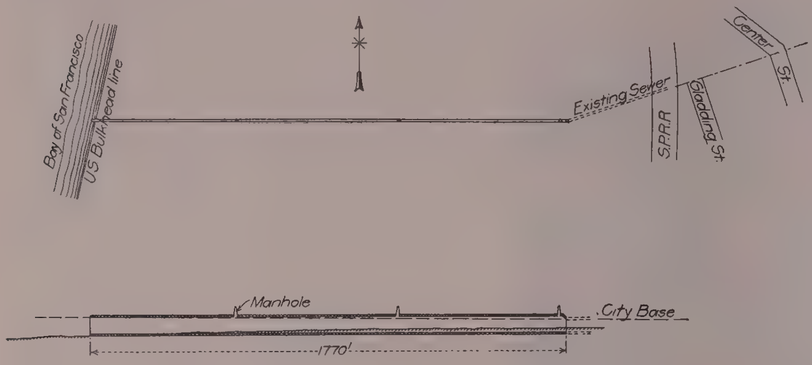
The bents carrying the floor on which the sewer barrel rests each have two piles, varying in length from 24 to 44 ft., and are spaced 8 ft. apart on centers. The piles in the rows are capped by 12 x 12-in. stringers, on which a tight floor of 4-in. plank is laid. The top of this floor is covered with at least 1 ft. of mud at all places, thus protecting it from wash and from attacks of the teredo, even though the tide flats are not reclaimed. Since some wash may occur at the off-shore end of the extension, thus exposing the timber structure at that point, the upper 10 ft. of the piles of the bent at that end and the upper 6 ft. of the next two bents were incased in a 30-in. steel cylinder, and these cylinders were filled with concrete reinforced with expanded metal. The timber stringers and floor were also replaced for 16 ft. at the end by two reinforced-concrete girders connected by a floor of concrete under the sewer barrel.

The Thirty-sixth St. sewer was built by the Mervy-Elwell Co. with a floating equipment, consisting of two scows and a pile driver. The bottom was dredged immediately ahead of the pile driver to below the depth of the stringers of the floor. The piles for the footing of the extensions were driven with the floating pile driver, which was allowed to rest on the bottom when the tide went out far enough to expose the bottom where pile driving was in progress. The piles were cut off and capped, and the timber floor laid during low tide, the men frequently working in water 2 ft. deep while this work was in progress. The sewer was built as fast at the timber footing was completed. One scow was moored on each side of the point where concrete operations were in progress, and the concrete was mixed on these scows and wheeled to place in the forms.

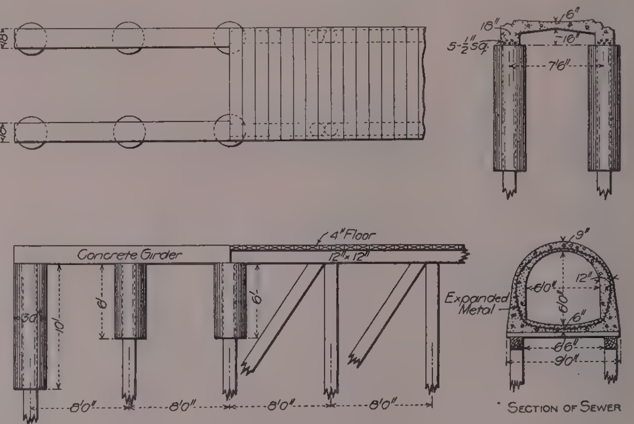
The construction of the main lake at Twenty-second St. outfall extension, built by the Atlantic, Gulf & Pacific Co., was handled in an entirely different manner. This outfall was rebuilt for 3,167 ft. back from the shore line and was also extended for 1,816 ft. from the latter. The extension has a horseshoe-shaped section, 6 ft. 2 in. wide by 6 ft. high, and is otherwise similar in design to the one at Thirty-sixth St. The grade of this extension brings its invert at the same depth as in the case of the one at Thirty-sixth St. The contractor first excavated the bottom to below the level of the stringers of the timber footing of the sewer with a suction dredge. The piles of the footing were then driven in this excavation by means of a floating driver.

A working platform, 12 ft. wide and 120 ft. long, was built on a specially-constructed timber crib, which had its under side cut to the shape of the outside of the sewer barrel, and was sheeted tight on all sides. This crib was designed so it could be seated on the floor of the footing for the sewer in such position that the sheeting of its under side would serve as the outer forms for the sewer. The original intention was also to pump out the crib, when the section of the sewer covered by it had been completed, in order that the platform could be moved ahead at high tide. The sides of the crib were not tight enough, however, to permit this method to be followed. Pontoons used for carrying the discharge pipe of the suction dredge were therefore attached to the crib at low tide when a move was to be made and as the water rose these pontoons lifted the crib and the platforms so they could be floated ahead.

The materials for the concrete were delivered to the platforms from scows at high tide, sufficient storage space being obtained on the sides of the platform for materials enough to last during at least one period of low tide. The concrete was mixed on the platform by hand and was shoveled directly into place in the forms. The inside forms for the sewer were built in sections and were knocked down and moved ahead after the concrete had set sufficiently. The concrete work was handled by a single 8-hr. shift, which generally started operations about 3 hr. before minimum low water and continued until the water rose so it interfered with the placing of the concrete.



Plan and Profile of Thirty-sixth Street Extension.



Details of Construction at Off-Shore End.

The piles were capped and the timber floor was laid immediately in advance of the concrete work. As the latter had been considerably delayed, the excavation made by the dredge had filled with silt so the timber work was handled through 1 to 2 ft. of this material at all times, occasioning much arduous labor.

In addition to the extensions of the outfalls, a large amount of new work has been done on the sewerage system of Oakland during the last two years, plans for a total expenditure of $600,000 having been executed, or placed under contract in that time. These plans were prepared in the office of Mr. F. C. Turner, city engineer of Oakland, and the construction work is prosecuted under his direction. Mr. Perry F. Brown is engineer in charge of the designing department of the city engineer's office.

A Double Cantilever Traveling Crane has recently been erected at one of the heavy freight storage yards of the Lancashire & Yorkshire Ry., at Liverpool. It has a capacity of 10 tons over a span of 172 ft., that is, at each end of the 86 ft. cantilever arms, and travels on a track of 28-ft. gauge. The long cantilever trusses are carried on two bents transverse to the track and spaced 40 ft. apart to allow logs of this length to be passed from one side of the yard to the other without being swung endwise. The crane is used principally for stacking timbers, and it can pile them 30 ft. high, the bottom of the cantilever arms being 43 ft. above the ground. The structure weighs 160 tons and is carried on twelve 3-ft. wheels. The speeds for handling 10 tons are as follows: Hoisting, 93 ft. per minute; carriage, 482 ft. per minute; crane travel, 435 ft. per minute.

Removing a Section of Brick Tunnel Arch.

In connection with the improvement work on the new Delaware, Lackawanna & Western R. R. tunnel through Bergen Hill, Jersey City, described in The Engineering Record of Nov. 9, 1906, the plans provide for another double-track bridge over the Erie R. R. tracks just west of the new tunnel portal, where these two railroads cross at an angle of 33 degrees, the Delaware, Lackawanna & Western R. R. being at the upper level. As the upper portion of the Erie R. R. tunnel extended across the new bridge location at such a height as would interfere with the construction of the new Lackawanna bridge, it was necessary to remove 40 ft. of the end of the brick arch. The situation at this point is clearly shown in an illustration on page 517 of The Engineering Record of April 18 last. The arch section was 28 ft. span, three-centered construction, consisting of five rings of brick, 18 in. thick, and had been in place since 1861.

Preparations had previously been made to close the Erie R. R. tunnel and do the work on May 10 from 1:15 A. M. to 6:45 A. M., and during that time the Erie R.R. trains were routed through the Lackawanna tunnel. For some days previous workmen had been engaged in removing the earth covering above the arch and coping stones at the portal. As soon as the arch was cleared 2-in. holes spaced from 1 to 3 ft. apart were drilled in a series around the ring of the arch every 2½ ft. along the section to be removed.

To receive the broken arch three gondola cars, half filled with cinders, with their upper edges protected with heavy timbers, and one flat car on the east end, were set on each track under the arch. Plug and feathers were inserted in each of the holes that had been made, and, commencing at the crown, the plugs were driven in to crack the ring from springing line to springing line. After the keystone was removed and an opening in the crown made, a 500-lb. weight suspended from a derrick placed to one side of the arch was dropped on top of the arch and many blows were necessary to knock down even a small section of the brickwork. This plan of breaking the arch was soon abandoned, and a small quantity of dynamite was placed in four or five holes of the crown. By this method a section of the crown about 10 ft. across the arch by about 5 ft. lengthwise of the arch was blown out. As the work of blowing out sections of the crown advanced the work of tearing down the remainder of the arch ring followed, the plug and feather method being used to crack the ring, which was then broken with sledge hammers, the mass falling into the cars below. As soon as the last section of the crown was blown out the gondola cars were removed and replaced with flat cars, on which were loaded the bricks that had fallen outside of the former cars. The work was all completed within the allotted time and traffic through the tunnel resumed.

The plug and feather method of cracking the arch ring was the same as used by the Delaware, Lackawanna & Western R. R. in removing the old tunnel arch at the shaft openings on their new Bergen Hill tunnel construction.

The engineering department of both railroads co-operated in doing the work, and this journal is indebted to Mr. A. L. Moorshead, resident engineer of the Erie R. R., for the foregoing data.

A 400-ft. Chimney to carry off fumes from the assay furnaces is a feature of the new 10-story Assay Office building of the U. S. Treasury Dept. which is under construction in New York City. The tall chimney is intended to carry the poisonous fumes entirely above the surrounding high office buildings in the neighborhood and thus eliminate the nuisance which has been caused by them.

Colloids in the Purification of Sewage.

Recent investigations in Germany and England have led to the conclusion on the part of the investigators that sewage is in a great part a colloidal solution of organic matter. This fact was first published in Germany in 1904 by Biltz and Kröhnke. It had also been recognized in England by Fowler and Ardern and by Jones and Travis. The subject has since been extended by these and other workers, and in particular numerous experiments have been made at the Hampton, England, sewage works. An explanation of the important part played in the purification of sewage, as deduced from the case of domestic sewage, the typical case on which most work has been done, was given as follows in a recent translation from the German by Mr. J. H. Johnston, chemist and bacteriologist of the Hampton Urban District Council, published in the "Surveyor," of London:

The colloids in sewage are of an organic nature, though they are frequently associated with inorganic matter. These colloids exist in a state of unstable solution, and have the characteristic of readily passing from the form of hydrosal (in solution) to that of hydrogel (in suspension). This change occurs both spontaneously and under the influence of outside agencies, such as surfaces, electrolytes and immiscible solvents.

In the bacteriological method of treatment of sewage, as indeed in all methods, the property of coagulation under the influence of surface action is the main factor which determines the clarification of the liquid. Spontaneous coagulation is not without influence on the result, but as it takes place at a very slow rate its effect is hardly manifest in the comparatively limited time of passage of the sewage through a treatment area.

In the tank operation, when the method of procedure is that of simple sedimentation, the only surfaces present are those forming the walls of the tank, and there is no opportunity for surface action on the bulk of the liquid. The immersed area of the walls, however, is always found to become covered with adherent matter, at first very fine, then becoming coarser and thicker, until the action of gravity on any portion becomes sufficient to cause it to detach itself and fall to the bottom, leaving the surface of the wall to become coated again. This deposit on the walls consists of coagulated colloid matter, together with some of the finest of the suspended solids in the sewage. When the surface area of any portion of the tank is increased by the insertion of separate slabs, as in the hydrolytic tank, the deposition effect is proportionately increased, for the surfaces of the slabs become coated with coagulated colloidal matter, and the liquid issuing from that portion of the tank contains a much smaller amount of colloids than would otherwise have been the case.

When the mode of tank operation is by septic processes there is an additional effect produced by the rising and falling of the sludge. By the generation of gas the sludge is from time to time either raised bodily or dispersed in fine particles through the liquid in the tank; this uprising has the effect of removing colloidal matter from the liquid by absorption on the sludge surfaces. When the gas escapes from the sludge through the latter reaching the surface or breaking up and the sludge falls again, the same removal of colloids takes place. When this action is frequent the liquid is rendered much clearer than at ordinary times, and contains a smaller amount of colloids. This explanation is to be preferred to that which attributes the absorption in a tank to a bacterial substratum in the liquid.

In the stage of the purification of sewage subsequent to the tank treatment, the liquid is passed through either contact or percolating beds, and it is here that the colloidal character of the liquid has the greatest influence on the purification process. These beds have been filled with materials of many kinds and of differing characters, but the principle of the action of the colloids is the same in each case and with either form of bed. When the liquid is held up in contact with, or is passing through, the material, it is exposed to a large surface area, and absorption takes place between the colloids in the liquid and the surface of the material in the bed. It is not necessary that such surface should be that of the actual material, it may also be, and with greater effect, that of the deposit on the material from a previous operation. Indeed, the deposited colloid not only encourages further deposition, but also absorbs that portion of the organic matter which is in true solution as well as some proportion of the ammonia and salts. The completeness of the absorption depends upon many factors, for instance, the concentration of the colloids in the sewage, the degree of stability of the colloidal solution, and the intimacy of the surface contact. The first two vary with the sewage treated, but the variations in different domestic sewages are not great, depending more upon differences in the systems by which the sewages are conveyed to the treatment area than upon differences in the chemical constitution of the sewages themselves, and they vary also in the same sewage at different times of the day. The last factor depends upon the size of the particles of the material in the bed, as the smaller the particles the greater the area of surface presented to the liquid passing through.

The effluent from the beds is deprived of colloids to an extent depending upon the circumstances above stated. Should the amount removed not be sufficient, the effluent is submitted to a second contact or a deeper percolating bed is used. Even in this case, however, it often happens that the whole of the colloids is not removed, as when their concentration in the liquid is very small their removal by surface action requires a longer time than can actually be given to the process in an artificial treatment area.

The colloidal matter absorbed on the material is subjected to physical, chemical, and biolytic actions. If the material is coarse, and there is a free current of air through the bed, these actions cause a change in the colloidal nature of the deposit, which from being glutinous becomes granular and readily detachable from the material, and it is washed out of the bed. If the material is fine, and consequently the air current slight, the colloidal character is much longer maintained, and the deposit remains in the bed for an indefinite time.

In the method of sewage treatment by chemical precipitation the reagents are added with the object of effecting the more ready subsidence of the suspended matter. At the same time some of the colloids in solution are also removed, as the precipitate produced presents a large surface area to the liquid and removes colloids by absorption. It is not possible in practice to attempt to coagulate more than a small proportion of the colloids by the addition of electrolytes, both because the varying concentration of the colloids prevents the addition of the electrolyte being calculated to the iso-electric point, at which point only is coagulation complete, and because of the cost involved.

In the natural method of purification of sewage by land treatment it has long been known that the soil, in addition to removing salts from solution, formed absorption compounds with the organic matter in the sewage, and that the soil whose particles presented the largest surface area removed the most organic matter. A knowledge of the colloidal nature of a substantial amount of the organic matter in sewage explains the readiness with which these actions were accomplished. If the fact that surface action was the cause of the removal of the organic and other impurities in the case of land treatment had been borne in mind when artificially prepared treatment areas were substituted for land, the correct explanation of the cause of the clarification obtained by the new method could hardly have been overlooked.

It is thus seen that there is a parallelism running through all the methods of sewage treatment, due to the colloid nature of the liquid, and that the known properties of the colloid state provide a clear explanation of the mechanism of the clarification process. A correct interpretation of this process is of the utmost practical importance, as otherwise no design for a purification plant could be drawn up with any assurance of success in actual practice.

Letters to the Editor.

Some General Impressions of the Isthmus of Panama.

Sir: There is no public undertaking anywhere of greater interest at the present time than the Panama Canal, and it has already begun to attract many visitors from America and Europe. Your readers may therefore be interested in some notes jotted down during a recent brief stay in the Canal Zone. No claim for exactness or comprehensiveness is made for these statements, as the official reports of the Isthmian Canal Commission are so admirable in their completeness and in their illustrations that the engineer in search of detailed information will find in them everything he desires. The purpose of this letter is rather to state some things of a general character concerning the isthmus and the canal work which will enable subsequent visitors to use their time to the best advantage and avoid intruding on the time of the engineers, who, from Colonel Goethals down to the lowest ranks, are working with a vigor and directness of purpose that make the spectator reluctant to bother them with inquiries or letters of introduction. This does not mean that visitors are not welcomed, for they are made to feel at home anywhere along the line, but rather that nobody connected with this vast undertaking has any time to waste answering foolish questions. And some of the questions asked certainly are indicative of a painful lack of mental fitness to grasp the work before the inquirer's eyes. For example, the writer was in one of the deep excavations, where some rock was encountered. An engineer connected with the work explained to a few visitors that the rock, which had a thick overburden of clay, was an argillaceous sandstone. One of the visitors seemed much interested in this statement, and after further inspection of rock face inquired of the engineer whether it was natural or artificial. Now such questions as that make a man busy with regular duties wish visitors who are not engineers would keep their distance. Intelligent questions are always cheerfully answered, however, and the engineer will find himself welcomed everywhere.

There are several methods of reaching the isthmus. The Hamburg-American Line runs steamers to Colon via Jamaica from New York, and during the winter supplements its regular fleet with an occasional excursion vessel. The Royal Mail Line also has a regular service between Colon and New York via Jamaica. The United Fruit Co. and the Leyland Line both have a regular service between New Orleans and Colon. There is also a regular service between Panama and San Francisco. The Panama R. R. steamship line between New York and Colon, which is controlled by the Isthmian Canal Commission, is the main route to the isthmus. The voyage takes six to seven days, depending on the ship, and the transportation charge is $90, which includes meals. The boats are clean and the food wholesome and abundant; the trip is made particularly interesting to the visitor, because most of the passengers are canal employees, and it is possible to learn from them many incidents and features of Isthmian life. In the passage south from New York the weather becomes warm soon after passing Cape Hatteras and gradually grows warmer until the Isthmus is reached. It is also likely to rain every day during a large part of the year. Sometimes the rains are mere sprinkles and at other times they are tropical downpours, when it seems as though a flood gate had been opened up aloft somewhere and a river were falling down on the land. These weather conditions make it advisable for the visitor to defer the purchase of clothes until he reaches Panama, for there he can buy a khaki suit which will shed water for $5, a panama hat for another $5, and a pair of canvas or leather leggings for any sum he considers desirable. Rubbers are useless, for they will be sucked off one's shoes after walking a short distance over the sticky clay soil. The leggings are necessary if the visitor goes out on construction very much; the ordinary clothing used by business men in the States will be ruined in a week's sightseeing. Low shoes will be filled with mud after walking a short distance on the work, although in the cities and towns, where the streets are paved or macadamized, they are as appropriate as on Broadway.

The ship docks at Cristobal, which is the American part of Colon, and if there is a wait of an hour or more before the train leaves it will be possible to see a good deal of the place by taking a cab driven by an English-speaking man and having him drive through the leading streets and out to the hospital. The town was formerly a low-lying, swampy place, with deeply rutted or muddy streets, swarming with mosquitos and naked children. To-day most of the streets are macadamized or paved with brick, the American houses are clean and attractive, and the houses outside American territory are fairly tidy. Everywhere the hand of the sanitary officer has left his mark. It was my good fortune to drive around the town with an American long resident on the Isthmus and for several years engaged in business in Colon. He testified that not only was the city vastly improved since the canal was begun, but as a result of the physical betterments and increased commercial life the people had raised their standards of living and thinking.

The first-class railway fare across the isthmus from Colon to Panama is $6.50. There are first and second-class cars, those who have the price taking the former invariably. They have comfortable wicker seats and are as clean as the cars in suburban service out of any of our American cities. There are three passenger trains from Colon to Panama and four in the opposite direction each day, and the running time is about 2½ hr. for the 47.58 miles. At places along the line it is possible to see something of the work, but it is wholly impossible to understand what is seen. Consequently the visitor who desires to become acquainted with the work will do well to avoid forming opinions from what he sees from the car window, simply endeavoring with the aid of the map he can buy at any news-stand to become familiar with the location of the stations and the general topographical features. Arriving at Panama, he can go to the Hotel Tivoli, where the rate is $7.50 a day, or to the Central Hotel, where the rate is about $5. The Tivoli is run by the Isthmian Canal Commission, and the canal employees receive much lower rates than that mentioned. The reason for the high rate to transients is diplomatic. According to our agreement with the Republic of Panama, we must not do anything to affect injuriously the business interests of Panamanian citizens, and as the Hotel Tivoli would seriously affect the Central Hotel and possibly some others if its rates were lowered, the high charge mentioned has been adopted.

The first place to visit is the Culebra cut. By leaving Panama at 6:35 a. m., it will be possible to reach Culebra by 7:10. The best plan for the visitor is to go to the Y. M. C. A. clubhouse, a walk of 15 minutes up hill where there is a good view down into the cut from the second-story veranda. After seeing the general location of the cut from this place, it is possible to walk down into it by a path which starts near a neighboring woodworking mill, where a number of Sikhs from India are employed. They are possibly the most noticeable race represented on the Canal Zone, although most countries have contributed to its cosmopolitan population. This is shown by the April police report, which states that 40 different nationalities were represented among the 591 arrests.

Almost down at the bottom of the Culebra cut is the office of the yardmaster of this section of the construction tracks, and from this point it is possible to obtain a good idea of the enormous magnitude of the cut and the vigor with which the work is being prosecuted. The well-sinking machines putting down blast-holes, the steam shovels, the network of pipes for supplying water and compressed air to the machines needing them, and the constant procession of spoil trains can be watched here better than anywhere else on the line. The whole morning can be profitably spent here, for the more one hears the testimony of the workmen regarding slides the more he recognizes the undesirability of attempting a sea-level canal, and the longer he watches the operation of the construction forces the better he appreciates the admirable organization of the men. The rainy season had begun in earnest when I visited the work, and everybody told me that the cut was then in the worst possible condition. The new tracks rested on a slippery clay, which became a semi-liquid glue when the water stood on it for any length of time. As a result, all track has to be ballasted as quickly as possible during the rainy season, for otherwise trains would be derailed constantly. Every time a derailment occurs there is danger of shutting down a shovel or delaying train service, and consequently the track-maintenance work is rightly considered very important. The yardmaster at this place sends daily about sixty trains to the La Boca dump and receives from it the same number of empties, in addition to managing a large amount of traffic on the construction tracks between the through tracks and the shovels.

An engineer can form a pretty fair impression of the work in the cut in a morning's observations, and then take the 12:22 train back to Panama, reaching that place in time for dinner. In the afternoon he will do well to drive to La Boca, and there see how the spoil from the portion of the cut he visited in the morning is handled. It will hardly pay him to try to investigate the details of dump management here, for after seeing the general scheme, which includes a breakwater from the mainland across the present channel used by strips to Naos Island, he will find the marine shops of great interest. At these shops a number of French bucket dredges have been repaired and put in commission and are now doing good work, some of them being in charge of men who operated them under the French. The shops have also repaired and put in commission a number of old French self-propelling hopper barges or clapets, which take the spoil from the bucket dredges to the dumps. The shops are well equipped and managed, and a large amount of old French marine apparatus is gathered there which deserves inspection.

The next morning might be devoted most profitably to an inspection of the enormous dump at Tabernilla, which can be reached at 8:03 by taking the 6:35 train from Panama. This great dump is 3 miles long, and an inspection of it should by no means be neglected, for the disposition of the materials from the heavy cuts is one of the most important features of the canal work. I mentioned above that the material in the cut at Culebra is very slippery. When it is dumped and then wet by the daily rains of this season it slips and sinks on the slightest provocation, and the only way of reducing this trouble is to mix the clay and rock so as to secure the most stable slope. On account of the peculiar character of the materials, this mixing requires a considerable experience with the local conditions, and some of the experienced dump foremen at different places on the line told me that they never encountered anywhere in the States such difficulties as they have to overcome here. The importance of the work can be recognized immediately from the fact that if the tracks on a dump are thrown out of commission for any reason, steam shovels and trains are also stopped in consequence, for the number of dumps is limited by the topographical conditions. Every possible method of keeping shovels and trains moving is taken, and the engineering force is striving all the time to improve the resources for handling spoil, so that the effect of an accident at any one place shall be reduced to a minimum.

The whole morning may profitably be spent at this dump, and dinner can be had at the commission's hotel at Tabernilla. These hotels are the boarding places of the company's American unmarried employees, who are charged 30 cents a meal, while visitors pay 50 cents. Thirty cents a meal suggests to the average New Yorker the leadlike bread and crowded, stuffy tables of a Childs' quick-lunch restaurant. I have eaten at many of the Commission's hotels and have invariably obtained better meals than I ever secured for the same money in any large American city. Soup, a good piece of steak, beef or fowl, more vegetables than I could eat, dessert, iced tea and coffee, all of good quality, were served in reasonable portions at tables placed so as to avoid any suggestion of crowding. I have been on construction work in many parts of America and Europe and never saw anywhere such good commissary service as exists on the Isthmus, which is all the more astonishing when it is considered that practically all the supplies must come from the United States. I was told that all the food supplies are purchased by sample, and the inspection of the materials delivered is under the charge of the food experts of the Department of Agriculture, the Canal Commission not being directly responsible for the quality of the supplies. An engineer who proposes to visit the Isthmus will do well to buy a 30-cent meal at one of the "quick-lunch" indigestion centers in one of our large cities just before coming down here, for he will then have something with which to compare the food furnished to canal employees for the same sum. I know nothing about the places where the colored laborers eat, but I visited one of the messes for white foreign laborers. Everything seemed clean and well managed, and the food was of the same general nature, stews, thick soups, hard-burned coffee and the like, that I have seen the same class of laborers eat in southern Europe, under much less cleanly surroundings, however.

By making friends with the yardmaster at Tabernilla, it will probably be possible to leave that place early in the afternoon on one of the empty trains going back from the dump to the Culebra division. The trains reaching Tabernilla are almost exclusively flat cars equipped for unloading by a Lidgerwood plow. At San Pablo, however, where the afternoon may be profitably spent, French locomotives and side dumpcars are used almost exclusively, and after watching their operation for a time one's estimation of the French equipment, already raised by acquaintance with the work of the ladder dredges at La Boca, will be raised again. San Pablo lies within Gatun Lake, which will be formed by the great earth dam at Gatun, and the excavation here is to cut the submerged ship channel. The work is being done with steam shovels, but part of it will also be done later by submerging the district and then finishing the channels by dredging.

Local excavation, such as is carried on at San Pablo, where the cuts do not exceed a few million yards, is not attended by the long hauls for spoil trains which is necessary in the case of the great cut forming the Culebra division. At San Pablo, for example, there is an ideal dump for the work in hand, which is well worth careful inspection. It would be well, moreover, when visiting such places to observe the numerous sheds for the shelter of the men in case of sudden heavy rains, although it is noteworthy that most men prefer to shelter themselves beneath a car. At this place and at a few more places on the Chagres division it is proposed to use "river dumps," where the spoil will be dumped down a bank of the Chagres River and then be washed into the stream by a jet of water. This can only be done at flood stages of the stream, but it is expected to prove decidedly economical. This place has some abandoned French dredging equipment which was not efficient, according to our notions, as the spoil was rehandled several times in moving it a comparatively short distance.

By taking the early morning train from Panama the next day it will be possible to reach Gatun at 8:43 and look over the beginning of the work on the great dam, spillway and locks. It will be rather difficult to understand the work by mere inspection at this time, but by asking questions of the foremen at the different parts of the operations it can be eventually comprehended. One thing the visitor surely should see—the native Panamanian village of Gatun. This is the best sample of local conditions as they were formerly that still remains on the Canal Zone. It should also be added that the visitor will find on inquiry that everybody at Gatun has unshaken confidence in the materials on which the locks will rest and on the stability of the great dike.

By leaving Gatun at 10:50 and returning to Pedro Miguel, lunch can be obtained there, and the afternoon left free for seeing the lock site there and walking to Miraflores, a short distance, and visiting the lock site and dump there. After completing this visit the engineer will be able to form his own itinerary for more detailed inspections. If the above program has been followed he will have only a very superficial idea of the work of sanitation, municipal engineering and mechanical engineering, which he may wish to examine. These things require special demands on the time of the health officers and engineers in charge of them, however, and no visitor should intrude on the arduous work of these men from motives of mere curiosity, professional or general. The visits outlined above can be made without bothering anybody, and, barring the rains, will entail less personal discomfort than must be suffered in New York, Philadelphia or Chicago during July and August. By wearing suitable clothes and carrying an umbrella, trifling inconvenience will be suffered, and an engineer with three weeks of vacation time will find it well spent in visiting the Canal Zone this summer. Yours truly, AQUARIUS.

Panama, May 16.

DATA REGARDING REINFORCED-CONCRETE PENSTOCK CONSTRUCTION.

SIR: We recently had occasion to make a careful investigation as to the use of reinforced concrete for penstocks. So little really helpful data were found, that we believe some of your readers would be assisted by the following list of references with notes, particularly as a majority of these refer to your own paper:

The Engineering Record, Vol. 47, Page 249.—Describes conduit at Champ, Isere, France, near Grenoble; 10.82 ft. diameter; hooped-steel concrete; walls, 7.87 to 9.84 in. thick; maximum pressure, 65.6 ft. of water; 6,890 ft. of reinforced concrete; no information as to waterproof qualities or effect of shrinkage.

The Engineering Record, Vol. 52, Page 648.—States that, owing to this tube's being buried, there is no variation on account of temperature changes and that the work is satisfactory.

The Engineering Record, Vol. 48, Page 725.—Cedar Grove Reservoir; 5 ft. in diameter; 4,000 ft. long; reinforced with expanded metal.

The Engineering Record, Vol. 49, Page. 72.—Conduit, Jersey City Water Supply Co.; 8½ ft. diameter, 3½ miles long; describes groove formed in face of concrete around its whole length to bond different days' work together.

The Engineering Record, Vol. 49, Page 191.—Torresdale Filter, varying from 7½ to 10 ft. in height.

The Engineering Record, Vol. 51, Page 562.—Penstock, Cornell University, Ithaca, N. Y.; 5 ft. diameter, 6 in. thick, 1,036 ft. long, ⅜-in. hoops, ¼-in. longitudinal bars.

The Engineering Record, Vol. 54, Page 171.

The Engineering Record, Vol. 55, Page 140.—Kaministiquia Power Co., Fort William and Port Arthur; 10 ft. inside diameter, 4 in. thick, 7,200 ft. long; operating under 15-ft. head; reinforced, 9/16-in. circular hoops in center of thickness of concrete, 6 in. apart; longitudinally, 5/16 in., 6 in. apart; after concrete had set, inside and outside surfaces were brushed clean and painted with tar and rosin.

The "Engineering News," Vol. 58, Page 116.—12½-ft. conduit, Huesca, Spain; length, 3,330 ft.; duplicate tubes; inverted siphons.

U. S. Reclamation Service, Belle Fourche Project, South Dakota, Specifications and Drawings, No. 145.—Gives details of reinforced concrete tube, 5 ft. diameter, 3,700 ft. long; hooped concrete walls, 8 in. thick; expansion joints used; details of these given in drawings; joints were coated with asphaltum.

Buford Trenton Project, U. S. Reclamation Service.—Shows pipe about 2,700 ft. long.

"Concrete and Reinforced Concrete Construction," by Homer Reid.—Describes Simplon aqueduct, extending from the River Rhone to Simplon Tunnel at Breig, Switzerland; 1.86 miles long, supported on trestles rectangular in shape; 8 or 9-ft. pressure. Also Salt Lake City aqueduct, 38,000 ft. long; partly in excavation, partly in tunnel and partly above ground; it is not subject to any internal pressure.

It is also stated that "sewers are usually built in monolithic lengths of not over 50 ft. to avoid shrinkage cracks, but if the section of the longitudinal reinforcement be designed to care for shrinkage from temperature stresses monoliths of any desired length may be built."

"Experiments on Concrete-Steel Pipes on a Working Scale," by John H. Quinton, U. S. Geological Survey.—Gives details of various joints used in experiments. This paper deserves careful attention, as the recommendation for covering reinforced concrete pipes is interesting, and the government authority for the publication would seem to give it standing.

"Principles of Reinforced Concrete Construction," by Turneaure & Maurer.—A typical authority for the theory that reinforced concrete can be built of indefinite length if properly reinforced and be free from practical defects from shrinkage, owing to temperature and setting stresses. The following quotation is practically substantiated by any other of the standard works on reinforced construction:

"When the structure is restrained by outside forces so that it is not free to contract or expand, as in the case of a long wall, then the resulting stresses are likely to be high. When not reinforced, concrete will under such circumstances crack at intervals, its maximum deformation under stress not being equal to its maximum temperature deformations. If it be assumed that concrete when reinforced will not stretch more than plain concrete, as seems probable (Art. 42), then no amount of reinforcement can entirely prevent contraction cracks. The reinforcement can, however, force such cracks to take place as they do in a beam—at such frequent intervals that the requisite deformation takes place without any one crack becoming large. Laboratory tests on beams would indicate that if steel is used in sufficient quantities the cracks may easily remain quite invisible and be of no consequence from any practical standpoint. Thus, if the coefficient of expansion be 0.000006, a change of temperature of 50° causes a change of length (if free) of 0.0003 part. A deformation of this amount in a beam (corresponding to a steel stress of 9,000 lb. per square inch) would not cause cracks easily detected. The prevention of large cracks by means of reinforcement is then a matter of using sufficient steel to force the concrete to crack at small intervals. No one crack will open up far until steel is stressed beyond its elastic limit, hence we may say approximately that the amount of steel used must be such that the concrete will crack elsewhere before the steel is stressed beyond its elastic limit. A larger amount of steel will serve to keep the cracks smaller.

"In calculating the requisite amount of steel the temperature stress in the steel itself must be considered. This will add to its shrinkage stress so that its total stress will equal its temperature stress, plus the stress necessary to crack the concrete. If, for example, the assumed drop in temperature be 50°, the temperature stress in the steel equals $50 \times 0.0000065 \times 30{,}000{,}000 = 9{,}750$ lb. per square inch. If the tensile strength of the concrete be 200 lb. per square inch and the assumed allowed stress (elastic limit) in the steel be 40,000 lb. per square inch, then the stress available equals $40{,}000 - 9{,}750 = 30{,}250$ lb. per square inch, and the required percentage of steel equals $p = 200 \div 30{,}250 = 0.0066$. If the elastic limit be 60,000 lb. per square inch the steel ratio equals 0.004. For the purpose here considered obviously a high elastic-limit is desirable, and, in order to distribute the deformation as much as possible, a mechanical bond is advantageous."

It would be very helpful if those having experience in this line of work would give available data regarding the use of contraction joints or the bonding of work together, in case such joints were omitted. Very truly yours,

Abertнaw Construction Co.,
Leonard C. Wason, President.

Boston Mass.

Reinforced-Concrete Column Design.

Sir: In your issue of April 4, 1908, I have read with much interest the article by Mr. E. P. Goodrich, describing the design and construction of the McGraw reinforced-concrete building. Prof. Wm. H. Burr has also given a very comprehensive description of this building, in the October, 1907, Proceedings of the American Society of Civil Engineers.

After a close study of these two articles, with especial attention given to the large amount of steel in the columns, the writer, with no intention or desire of criticizing in any manner the merits or demerits of this design, wishes only to offer a few remarks relative to a possible solution in eliminating the excessive use of steel in concrete columns. It is obvious from our present knowledge of steel and concrete acting in unison to resist compression, that the ultimate safe value of the steel cannot be obtained when the two materials are stressed simultaneously.

Since the present stage of concrete construction is one of more or less experiment and compilation of facts, some new method of construction, that will probably prove economical only in the case of tall buildings with heavy live loads, might be devised and eventually perfected by which the steel columns, prior to encasing with concrete, could be subjected to initial stresses, due to the dead loads of completed floors above, and proportioned so that the final stress in the steel would be about 16,000 lb. per square inch, allowing the concrete its value in assisting to resist the secondary cr live-load stresses. This method of construction, to obtain the desired initial stresses in the steel, would necessitate the use of some form of steel skeleton for the girders of the floor system, riveted to the columns, so that the dead load of the concrete in the floors could be supported, and erection done with facility in permitting the forms to be hung from the steel of the girders. A riveted skeleton of this nature would afford rigidity to the structure, during erection, which is almost impossible in the ordinary concrete building design.

The concreting of the floors offers the greatest problem. In allowing the columns to remain bare during the construction of all the floor systems, assuming a floor plan similar to the McGraw building, considerable difficulty would probably be encountered at the juncture of beams and girders with the columns, and this could possibly be surmounted in the case of the beams by employing angle brackets extending out the required distance from and riveted to the steel columns, to support the beam concrete and securely engage the ends of the rods, reinforcing the beams. Of course, since the loads carried by the beams are comparatively small, riveted trusses for reinforcement would not be economical.

If only that portion of the column adjoining the floor system were to be concreted at the same time with the floor, it is a question whether or not the initial stresses in the steel transmitted to this small portion of concrete encasing, would be objectionable from a theoretical standpoint, but certainly would be when the concreting of the columns was in process, on account of the inaccessibility occasioned by closing the entrance to the column forms at each floor level. It is obvious that the portion of the steel in the beams and girders, which remains temporarily unencased in the opening left around the column, would necessarily be designed to resist all shear due to the dead load of the floor system, before any support is offered by the concrete of the columns. It would seem at first that the portion of the floor system immediately surrounding the column would offer an objectionable point of weakness, and no doubt this objection could be obviated by stopping the concrete of the beams and girders at an angle of say 30° or 45° with the vertical, so that when the columns are concreted the connection will be a perfect one and permit of any arch action in the concrete of the beams or girders.

By stressing the steel of the columns to 16,000 lb. the space saved by the reduced size of the finished column would be a very material one.

By employing this method of construction, in order to illustrate the saving of steel in a building of the McGraw type, take for example the second story column of this structure. The dead and live loads sustained by this column is about 761,300 lb., of which 360,300 lb. is the initial or dead load to be taken by the steel column alone. By using a star-shaped column made up of four 6 x 4 x 1-in. angles, the steel area of 36 sq. in. taking the initial load of 360,300 lb. would be stressed to 10,008 lb. per square inch. Assuming that the concrete in a column of this section is good for a maximum working stress of 500 lb. per square inch and further that the ratio between the moduli of elasticity for the concrete and steel being assumed as 12, the corresponding working stress in the steel would be 6,000 lb. per square inch. A column 20 x 20 in. will be required to develop the secondary stress of 6,000 lb. per square inch in the steel, since the load taken by the concrete and steel acting together is 401,000 lb. The steel has therefore a final stress of 10,008 lb. + 6,000 lb. = 16,008 lb. per square inch. Hence we have a column 20 x 20 in. with 36 sq. in. of steel, against a corresponding column in the McGraw building which is 26 x 26 in., with 45.9 sq. in. steel. The second story column of this building contains four 8 x 6 x ⅞-in. angles. In this column designed as above a saving of about 33 lb. per foot is gained and besides a reduction in space occupied by the finished column, a saving of about 2 cu. ft. of concrete per foot of column.

In referring to the floor system, the same arrangement of beams and girders as in the McGraw building is assumed. If a latticed steel truss is used in the girders, the lower flange of course would be designed to take all tension. Then assuming, as for the columns, the concrete in compression to have a working stress of 500 lb. per square inch and that the ratio between the moduli of elasticity for the concrete and steel is 12, the upper flange of the truss could be proportioned to take all the initial stresses due to the dead load of wet concrete, supported by forms hung from the truss, stressing the steel to about 10,000 lb. per square inch, so that the remaining available stress of 6,000 lb. per square inch could be proportioned with the upper third of the concrete girder, to take the secondary or live load stresses, assuming the upper third to act virtually as a column.

As before stated, it is not claimed by the writer that the above method of design and construction would be economical in all cases, for it is obvious that in a building designed for live loads, the steel trusses for the girders, in the first place, could not be economically employed, since the upper flange would be more or less a waste of steel.

Owing to the wonderful strides that reinforced concrete has made as a building material, the one principal fact of its superiority as a fireproof material alone will greatly encourage its general use in tall buildings designed for heavy live loads, provided some method of design and construction is perfected wherein the steel can be used economically with a consequent reduction in the final cost. Yours truly,

Washington, May 20, 1908. W. J. Knight.

[The idea of Mr. Knight to give initial stress to the steel reinforcement prior to completing the concrete parts of columns has much merit, and has already been seriously considered by engineers. In fact, it is understood that the steel reinforcing ribs of the 725-ft. Henry Hudson memorial arch will receive a large initial stress of that character.—Ed.]

Rapid Engine Erection was recently accomplished at the Davidson Rubber Works in Charlestown, near Boston, Mass. The old engine was wrecked one evening when it was being shut down. Two days later an order was placed with the Allis-Chalmers Co. for a 20 x 48-in. engine and the foundations for it were started. This engine was shipped by express three days after the contract was let and arrived at its destination two days later. Parts of the old engine, such as the wheel and shaft, were used again and the crank was rebored to take a new pin. In the meantime the foundation had been finished. By midnight, five days after letting the contract, the engine had been delivered and placed on the foundation, after which a few hours were allowed to elapse for the concrete to dry out. The assembling of the parts was begun, the new piping was put in and the engine was turned over three days later. The next day a light load was put on and the next day, ten days after placing the order, the engine was put in regular service.